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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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VOL. CVII.—No. 2771.] *LONDON: FRIDAY, FEBRUARY 7, 1919.* [*Registered at the General Post Office as a Newspaper.*] PRICE, 9d. BY INLAND POST ... 11d.

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See Illustrated Advertisement
Page 116, Jan. 24.

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All British Hardened Steel.
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For Illustrated Advertisement, see page 32. 7356

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See page 123, Jan. 31. 7262

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6020
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See Advertisement page 99.

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LIVERPOOL WAREHOUSE—63, PARADISE ST.
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CARDIFF WAREHOUSE—123, BUTE ST.
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See Advertisement page 28. 7268

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See Illus. Advt. last week, page 15. 7046

See's Patent Hydro-Pneumatic Ash Ejector.
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Chief Works and Offices:
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London Office: 6353
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See Advertisement page 53, Jan. 17. 3402
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Tele. Address: "FUELECON, Phone, London."

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Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND.
7008
See half-page Advertisement page 56, Jan. 24.

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Power Hammers,
Drop Stamps,
Band Saws. 7256
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The Manchester Steam Users' Association.

For the Prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.
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Patents and Designs Act, 1907.

Notice is Hereby Given that

JOHN LOWE and JOHN JAMES LYTH, both of Montreal Cottons, Limited, in the City of Valleyfield, Quebec, Canada, seek leave to amend the specification of Letters Patent No. 114205, granted to them for "Method of and apparatus for straightening weft threads."

Particulars of the proposed amendment were set forth in the Illustrated Official Journal (Patents) issued on the 29th January, 1919.

Any person, or persons, may give notice of Opposition to the Amendment by leaving Patents Form No. 18 at the Patent Office, 25, Southampton Buildings, London, W.C., within one calendar month from the date of the said Journal.

W. TEMPLE FRANKS,
Comptroller-General.

LLOYD WISE & CO.,
Chartered Patent Agents,
10, New Court, Lincoln's Inn,
London, W.C. 2,
Agents for the Applicants. S 440

Patents and Designs Act, 1907.

Notice is Hereby Given that

ALLDAYS & ONIONS PNEUMATIC ENGINEERING CO., Ltd., of Great Western Works, Sydenham Road, Birmingham, in the County of Warwick, Engineers and Manufacturers, and PHILIP JOHN WILSON, Mechanical Engineer, at Great Western Works aforesaid, seek leave to amend the specification of Letters Patent No. 114749, granted to them for "Improvements in or relating to drop stamps."

Particulars of the proposed amendment were set forth in the Illustrated Official Journal (Patents) issued on the 29th January, 1919.

Any person or persons may give notice of Opposition to the Amendment by leaving Patents Form No. 18 at the Patent Office, 25, Southampton Buildings, London, W.C., within one calendar month from the date of the said Journal.

W. TEMPLE FRANKS, S 442
Comptroller-General.

London Association of

FOREMAN ENGINEERS.
Established 1853.
Foremen, Managers and Employers connected with the Engineering Industry.
MONTHLY MEETINGS are held at the Cannon Street Hotel, E.C.
Membership is not confined to residents in London.
Secretary:
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LONDON COUNTY COUNCIL.

Westminster Technical

INSTITUTE, Vincent Square, S.W. 1.

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A Special Course of about 20 LESSONS on the PRINCIPLES OF DESIGN IN REINFORCED CONCRETE, will be delivered by H. SPRAGUE, Esq., A.M.Inst. C.E., on Friday evenings from Seven to 9.15 p.m., commencing on 31st January, 1919.

These Lessons are arranged for Civil Engineers, Naval Architects, and others, and in addition to a discussion of the fundamental principles upon which the usual calculations are based, practical examples will be worked out, and calculations will conform to the L.C.C. regulations where necessary.

Fee for the course 5/-.

Application forms and syllabus of the course may be obtained on application at the Institute.

JAMES BIRD, S 324
Clerk of the London County Council.

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TENDERS.

THE GUARDIANS OF THE POOR of the Parish of Nottingham invite Engineering Firms to—

Tender for the Installation at

their Bagthorpe Institutions, Nottingham, of PLANT to obtain "Induced Draught" at their Boilers.

A specification of requirements may be obtained from my Office, 50, Shakespeare Street, Nottingham.

Sealed Tenders must reach me not later than the 3rd proximo.

J. ALLAN BATTERSBY,
Clerk to the Guardians.
5th February, 1919. S 557

STEPNEY BOROUGH COUNCIL.

ELECTRICITY SUPPLY.

BOILERS AND BOILER-HOUSE ACCESSORIES.

The Electricity Supply Committee of the Stepney Borough Council invite

Tenders from Responsible

Contractors for the manufacture, supply, delivery and erection of TWO WATER-TUBE BOILERS, together with Chimneys, Economisers, Flues and all other accessories specified.

Copies of the general Conditions, Specification, Form of Tender and Drawing may be obtained from Mr. Wm. C. P. Tapper, M.I.E.E., Borough Electrical Engineer and Manager, No. 27, Osborn Street, Whitechapel, E. 1., upon receipt of a deposit of five guineas. Deposits will be returned to *bona fide* Tenderers after the tenders have been considered.

Tenders, on the form supplied, endorsed "Tender for Boilers," must be delivered, signed, sealed and addressed to the Chairman of the Electricity Supply Committee, at No. 27, Osborn Street, Whitechapel, E. 1, not later than Noon on Thursday, February 20th, 1919.

The Council do not bind themselves to accept the lowest or any tender.

GEO. W. CLARKE,
Town Clerk.
Municipal Offices,
15, Gt. Alie Street, E. 1.
February 3rd, 1919. S 506

MUNICIPAL COUNCIL OF SYDNEY, N.S.W.

The Council is prepared to receive

Tenders for the Supply,

DELIVERY and ERECTION, in the Council's Power House, Sydney, New South Wales, of BOILER HOUSE EQUIPMENT, including automatic stokers, storage bunkers, conveyers and auxiliary plant.

Copies of the Specification and General Conditions and Form of Tender, together with drawings, may be obtained On and after February 17th, from Messrs. Preece, Cardew, Snell & Rider, 8, Queen Anne's Gate, Westminster, S.W. 1, on payment of a deposit of £1-1-0.

Sealed Tenders, endorsed "Boiler Plant" are to be addressed to the Town Clerk, Town Hall, Sydney, N.S.W., and delivered to him on or before three p.m. on Monday, May 19th, 1919.

The Council does not undertake to accept the lowest or any Tender S 281

CITY OF LINCOLN.

ELECTRICITY DEPARTMENT.

The Lincoln Corporation invite

Tenders for the Manufacture,

DELIVERY and ERECTION in Lincoln of the undermentioned PLANT, viz.:—

Section A.—Four Water Tube Boilers, with induced draught plant, stokers, and other auxiliaries.

Section B.—Two 3000 k.w. Turbo-Alternators, with condensing plants and auxiliaries.

Section C.—Extension of Extra High Tension Switchboard, and also exciter and other panels.

Section E.—Two 750 k.w. Rotary Converters, with static transformers.

Section F.—Two 2000 k.v.a. 3-phase Transformers, 6600—3300 volts.

Tenders will be considered for any of the above Sections.

Specifications and other particulars may be obtained by manufacturers on application to the Consulting Engineers, Messrs. Preece, Cardew, Snell & Rider, 8, Queen Anne's Gate, Westminster, S.W. 1.

Copies of the specifications can be seen at the office of the City Electrical Engineer, Mr. STANLEY CLEGG, Brayford, Lincoln.

Tenders, upon the prescribed forms, must be delivered at the Town Clerk's Office, Guildhall, Lincoln, not later than Eleven o'clock a.m. on Wednesday, March 5th, 1919.

An official receipt must be obtained for any Tender delivered by hand. Tenders sent by post must be registered.

The Council do not bind themselves to accept the lowest or any Tender. S 458

CITY OF BIRMINGHAM.

TRAMWAYS DEPARTMENT.

ELECTRIC TRAMWAY CARS.

The Tramways Committee are prepared to receive—

Tenders for the Supply,

DELIVERY, and ERECTION OF ADDITIONAL ROLLING STOCK.

A Form of Tender, with instructions, general conditions, specification and drawings can be obtained on application to the undersigned at the Tramway Offices, The Council House, Congreve Street, Birmingham, on payment of £2, which will, after the Committee shall have come to a decision upon the tenders received, but not before, be returned to the tenderer, provided he shall have sent in a bona fide tender

Persons Tendering must at the time of Tendering and at all times during the execution of the work be paying all their workpeople (except such as may be employed under special provisions agreed upon by the employers and the local organised bodies of workers) not less than the Trade Union or Standard Rate of Wages in the several districts where the work people are actually engaged in the execution of the works, and must also be observing the hours and conditions of labour, as well as the aforesaid rate of wages, recognised by the Associations of Employers and the Local Organised Bodies of Workers in the various trades in the several districts where the works are being done. The Tender of any Contractor who does not pay the Trade Union or Standard Rate of Wages or observe similar conditions in his ordinary business will not be accepted.

Tenders must be enclosed in a sealed cover, addressed to the Chairman of the Tramways Committee, The Council House, Congreve Street, Birmingham, and endorsed in the left hand corner, "Tender for Rolling Stock," and must be handed in not later than Ten o'clock on Wednesday, the 5th March, 1919.

The Tramways Committee do not bind themselves to accept the lowest or any tender.

ALFRED BAKER,
General Manager.
Tramway Offices,
The Council House,
Congreve Street,
Birmingham. S 465

SALE OF GERMAN SUBMARINES.

The Admiralty Offers for

SALE a number of GERMAN SUBMARINES as they lie in England, Scotland and Ireland, at Harwich, Rosyth, Buncrana and other Naval Ports.

The boats will be sold for breaking up only, under bond and inspection.

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APPOINTMENTS OPEN.

THE COUNTY TECHNICAL AND SECONDARY SCHOOL, WORKINGTON.

Wanted, an Assistant Master

(Graduate) in the Engineering Department. Commencing salary £250, subject to advances according to scale not yet completed.—Apply, PRINCIPAL, S 71

ROYAL TECHNICAL INSTITUTE, SALFORD.

Principal—B. Prentice, D.Sc., Ph.D.

Lecturer in Electrical Engineering

WANTED, to commence March 1st. Engineering degree and works experience essential. Salary according to scale and teaching experience.—Particulars and forms of application may be obtained from the SECRETARY to the Education Committee, Education Office, Chapel Street, Salford, and must be returned not later than February 19th. S 501

L. C. EVANS, Town Clerk.

HULL EDUCATION COMMITTEE.

MUNICIPAL TECHNICAL COLLEGE.
Principal, Mr. T. LUXTON, B.A., B.Sc. (Lond.).

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An Assistant Lecturer on

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Forms of application may be obtained from the undersigned on receipt of a stamped addressed foolscap envelope, and must be returned so as to reach these offices not later than the 21st February, 1919.

J. T. RILEY,
Director of Education.
Education Offices,
Albion Street, Hull.
3rd February, 1919. S 541

UNIVERSITY COLLEGE, NOTTINGHAM.

LECTURER IN ELECTRICAL ENGINEERING.

The Council of the College invite

Applications for the Post of

SENIOR LECTURER in Electrical Engineering, commencing salary £300 per annum.

Further particulars and application forms may be obtained from the Registrar, to whom applications must be sent not later than 3rd March. S 508

CITY OF CARDIFF EDUCATION COMMITTEE.

THE TECHNICAL COLLEGE.
Principal, CHARLES COLES, B.Sc. (Lond.).

The Services of the following

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Commencing Salary £600 per annum.

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Commencing Salary £350 per annum.

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Applications on foolscap paper, stating age, full qualifications, teaching and other experience, and giving copies of not more than three testimonials, should reach the Principal (from whom further particulars may be obtained) by the 17th March, 1919.

Relatives of eligible men on War Service are requested to bring this advertisement to their notice.

JOHN J. JACKSON, B.A.,
Director of Education,
City Hall, Cardiff. S 476

LIVERPOOL EDUCATION COMMITTEE.
MARINE ENGINEERING.

Application (which must be

received on or before Saturday, 15th Feb. 1919) are INVITED for the POSITION of ASSISTANT INSTRUCTOR OF MARINE ENGINEERING at the Central Municipal Technical School. Commencing salary £460 per annum, together with War bonus according to scale.

For particulars of the qualifications necessary and desirable, with particulars and conditions of appointment and forms of application, address—

J. G. LEGGE,
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E. R. PICKMERE,
Clerk to the Education Authority. S 391

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NOTICE.

BOMBAY MUNICIPALITY.

Applications are Invited for

the POST of ASSISTANT ENGINEER, ROADS, in the Public Works Department of the Bombay Municipality.

(2) Applicants should have had at least 15 years experience in road construction and maintenance with various materials and should have held an appointment as Chief Surveyor, with the control and direction of large bodies of workmen. They should be experienced in quarrying operations preferably in trap rock, have knowledge of stone setting and wood paving, have practical experience of tar and bituminous construction work, and fully understand the use and application of the relative mechanical appliances.

(3) The duties of the post will consist chiefly in organizing labour, in guiding and training the staff in modern scientific methods, and in closely supervising the construction of, and repairs to, all Roads and Streets within the jurisdiction of the Municipality and under the direction of the Executive Engineer.

(4) Preference will be given to candidates who have qualified as Members of the Institute of Civil Engineers or of the Municipal and County Engineers and who have had experience of Road Board Work.

(5) Age should be between 30 and 45 years.

(6) The appointment has been sanctioned provisionally for a period of five years at a salary of Rs. 800/- per mensem rising to Rs. 1,000/- per mensem by annual increments of Rs. 50/-. A conveyance allowance of Rs. 100/- per mensem is attached to the post.

(7) The successful candidate will be required to produce a certificate (from a competent source) of fitness for service in the tropics.

(8) The successful candidate, if appointed in India will be allowed first class railway fare to Bombay, and if appointed from the British Isles a first class free passage out to Bombay with full pay during the voyage.

(9) One month's privilege leave for every 11 months' active service subject to a maximum of 3 months at one time will be allowed.

(10) Applications with one copy each of three recent testimonials should be addressed to the Undersigned and should reach him not later than 15th April, 1919. Applicants should state the earliest date on which they can take up the appointment after receiving intimation of appointment.

JAMES W. MACRISON,
B.Sc., M.Inst.C.E.,
Executive Engineer,
Bombay Municipality.
Municipal Offices, Bombay,
9th January, 1919. S 449

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CIVIL AERIAL TRANSPORT—FLYING THE ATLANTIC.

By G. GREENHILL.

A HUNDRED years ago the steamship had come into commercial use, for a voyage as far as the Baltic and Mediterranean. But the Atlantic passage had not yet been attempted, over such a wide and wild sea, a diameter of action of nearly 3,000 miles, in a steamer of the size of those days, capable of using the terminal ports. As soon, however, as the voyage was accomplished as an experiment, and the requirements were known of cost and fuel, it was a simple problem for a Lardner to work out the commercial details for the encouragement of the merchant. The Admiralty would take no share till long after success was assured.

The ruling difficulty of that time was the limitation imposed by a terminal port to the size of the steamship; and we have seen later how the Great Eastern could never be a commercial success because no dock was available for repair.

To-day we are confronted with the same material calculations in a similar problem for the airship and flying machine, of a projected passage across the Atlantic, although it is not ten years since Blériot's flight across the Channel was hailed as an unprecedented feat.

In the airship the chief difficulty will be at the start and landing again, to be done in all weather at an assigned spot. The time up in the air is unlimited for practical purposes, and a diameter of action of 3,000 miles is not unreasonable to expect. Adverse head wind can be avoided by a change of level up in the air, provided the pilot has some instrument for measuring his speed over the earth. His air log merely measures the travel through the surrounding air, and ignores the wind current. So, too, the log in the water would not record any ocean current or tide effect.

But in the flying machine the limit of diameter of action is to-day about 600 miles, non-stop, and the theoretical question is how is this to be increased about four-fold?

In my lectures on the "Dynamics of Mechanical Flight," I stated a theorem to show that increase of diameter of action must be made by increase of speed, on the same consumption of petrol; making a comparison between the ancient Newtonian theory, where the air is taken to behave dynamically like a cloud of dust, and the modern discontinuous-flow theory of Helmholtz and Kirchhoff. The two rival results are described as the square sine law, and the simple sine law.

At normal incidence the two results are taken to agree; but at the small angle of attack required in an aerofoil wing the square sine law of Newton assigns a lift too small to be useful, and so this ancient theory condemned the possibility of aerial flight. But on the sine law the lift is found to be ample for ascent into the air, and the flying machine is to-day a practical justification of this new Helmholtz-Kirchhoff theory.

If the effective slope of the chord of the cambered wing is one in n (say about 1 in 6 to 10) the machine is being driven, as it were, up an incline of 1 in n.

It is found that a pressure of 1 lb. per square foot is exerted on a plane area by a wind blowing perpendicular to the plane with a speed of about 12 knots; and thence the normal pressure of a K knot wind is $\left(\frac{K}{12}\right)^2$, lb/ft².

On the simple sine law, the normal thrust on a wing of area A ft.², at an angle of attack of 1 in n, would be $\frac{A}{n}\left(\frac{K}{12}\right)^2$ lb, and this must be equated to W, the weight of the machine in pounds, for the maintenance of the flight up in the air.

The propeller thrust T must be $\frac{W}{n}$ lb.; and taking 1 H.P. as 330 knot.-lb, the effective

$$\text{H.P.} = \frac{K\,T}{330} = \frac{K\,W}{330\,n} = \frac{K}{330}\cdot\frac{W}{A}\left(\frac{12}{K}\right)^2 = \frac{144\,W^2}{330\,A\,K}$$

varying inversely as K.

Given the petrol consumption at p lb/H.P.-hour, then over a diameter of L nautical miles, in $\frac{L}{K}$ hours at K knot speed, the petrol required is:

$$P = \text{H.P.}\,\frac{L\,p}{K} = \frac{W^2\,L}{330\,A}\left(\frac{12}{K}\right)^2 p, \text{ lb,}$$

varying inversely as K², showing the advantage of high speed. An increase of speed from 100 knots to 140 knots would halve the petrol to be carried, or double speed over the journey would require quarter fuel.

For an m-fold diameter of action of the same machine, on the same petrol, the speed must be raised to $K_1 = K\sqrt{m}$ knots.

Thus if the 600-mile flight is to be extended to a non-stop run of 2,400 miles, the speed must be double, and the time too; so that the same petrol lasts longer, and the horse-power can be reduced by the divisor $\sqrt{m}$ in the general case. But this paradoxical result implies that the angle of attack is diminished from 1 in n to 1 in $m\,n$; and such small angles are unsuitable from the instability of their action. For if the machine was to duck through an angle of 1 in n, it would start a nose dive. And head resistance has been ignored, not contributing to lift.

If safety and stability require that the angle of attack should vary only slightly from a mean value of 1 in n, the petrol P to be carried for a non-stop run of L miles at K knots is, from the above:

$$P = \text{H.P.}\,\frac{Lp}{K} = \frac{W\,L\,p}{330\,n}, \text{ or } \frac{P}{W} = \frac{Lp}{330\,n}.$$

Suppose $P = \frac{1}{2}W$ for a very long run, and take $n = 10$, then $L\,p = 1{,}100$. Thus p must be reduced to 0·5 lb./H.P.-hour to make L = 2,200 miles, a non-stop run across the Atlantic.

Similar calculations can be made on the ancient square sine law of Newton.

But head resistance is too important to be omitted in these calculations. Suppose, then, it is the equivalent of a vertical plane, B sq. ft., driven head to wind and making a head resistance $B\left(\frac{K}{12}\right)^2$ lb, to be added to the previous propeller thrust, giving a total thrust:

$$T = \frac{W}{n} + B\left(\frac{K}{12}\right)^2 = \frac{W^2}{A}\left(\frac{12}{K}\right)^2 + B\left(\frac{K}{12}\right)^2, \text{ lb.}$$

and requiring horse-power and petrol P for L miles.

$$H\,P = \frac{K}{330}\left[\frac{W^2}{A}\left(\frac{12}{K}\right)^2 + B\left(\frac{K}{12}\right)^2\right].$$

$$P = \frac{p\,L}{K}\cdot\frac{K}{330}\left[2\,W\sqrt{\frac{B}{A}} + \left(\frac{W}{\sqrt{A}}\frac{12}{K} - \sqrt{B}\,\frac{K}{12}\right)^2\right]$$

an economical minimum when 50 per cent. of the power is expended against head resistance, and the rest in driving up the air incline, and then

$$P = \frac{2\,p\,L}{330}\,W\sqrt{\frac{B}{A}}, \quad \text{when } \frac{W}{\sqrt{A\,B}} = \left(\frac{K}{12}\right)^2 = \frac{W\,p}{A};$$

and then $n = \sqrt{\frac{A}{B}}$, $A = n^2\,B$, or n feet square of wing area to 1 sq. ft. of head resistance area.

The most favourable value of n may thence be inferred from an estimate of the ratio of A to B; or else this ratio is given from the value of n found best in practice.

Then $\frac{P}{W} = \frac{2\,L\,p}{333\,n}$. Thus, if one-third of the weight lifted is assigned on the average to petrol, $P = \frac{1}{3}W$, $L\,p = 55\,n$; that is $L\,p = 330$ for $n = 6$, making $L = 660$ miles with $p = 0{\cdot}5$ lb./H.P.-hour, an economy of consumption as yet hardly attainable.

We read that the Handley Page machine which flew to Constantinople weighed 6½ tons, with 700 h.p. for an average speed of over 60 knots, for a run of 3,000 miles in 50 hours, including stoppages.

Taking $p = 1$ as a more likely figure of present performance, then with $n = 10$, L = 550 miles; and five of these flights would land the machine at 250 miles from Constantinople, a radius of action favourable for the bombing attack, and return to the base.

With a wing span of 100 ft., assume A = 2,500 ft.², making the wing loading $\frac{W}{A} = \frac{13\frac{1}{2}\times 2240}{2500}$, nearly 5 lb/ft.²; and then $K = 12\sqrt{\frac{W\,n}{A}} = 84$ knots, covering 550 miles in 6½ hours, allowing 3½ hours at a halt.

At this speed of 84 knots, the effective horse-power works out to:

$$\text{H.P.} = \frac{K}{330}\,2\,\frac{W^2}{A}\left(\frac{12}{K}\right)^2 = 750, \text{ against 700,}$$

the number given, or 20 lb/H.P.; so that the flying speed would be rather less, say 80 knots, allowing 3 hours for a halt, to 7 hours in flight.

To raise the 550 miles four-fold to 2,200 miles, for an Atlantic flight, would require p to be reduced to 0·25 lb/H.P.-hour, which is beyond present attainment.

A flying machine to bomb Berlin is described as weighing 15 tons, with wing span 130 ft., say A = 6,720 ft.² at wing loading 5 lb/ft.².

With horse-power 1,400, the speed:

$$K = \frac{2\,W}{330}\cdot\frac{\frac{W}{A}}{\text{H.P.}}\cdot 144 = \frac{30\times 2240\times 5\times 144}{330\times 1400} = 105 \text{ knots.}$$

It would require a radius of action of at least 300 miles, to make a start out at sea beyond Heligoland; and then with L = 600 $n = 10$, $p = 0{\cdot}9$. The bombing flight, there and back, would then occupy about 6 hours.

So far the effect has not been considered of the gradual consumption of the petrol, and the consequent diminution of W in flight.

But when this is taken into account, it will be found that, at a constant speed K knots, the length of a flight can be increased in the ratio of W to W − P before the petrol is all consumed; that is, 50 per cent. with $P = \frac{1}{2}W$ at the start.

In all these calculations the nautical units of the sailor should alone be employed; his knot for speed, and the nautical geographical mile for distance. The statute mile, old Roman military land mile, should never be mentioned, or a reckoning in land miles an hour. But the kilometres an hour is acceptable, exactly 0.54 of a knot.

The attenuation of the atmosphere in flying at a great height is allowed for by a change in the constant 12 knots at sea-level to $12\sqrt{s}$, where s is the relative specific volume of the air, as the velocity to give a normal pressure of 1 lb./ft.².

Thus at a height of 15,000 ft. to 20,000 ft., where the air density is halved, 12 would require to be raised to 17, and to maintain the flight the speed K would have to be doubled, and the horse-power too, with doubled revolutions; but the petrol consumption for a flight would remain the same.

These are the elementary considerations to be faced in looking at the problem of the Atlantic flight on an aeroplane. An airship can be treated like a long-voyage steamer, on Froude's laws, as in the article on page 20 of ENGINEERING, of January 3 last.

But the flying machine service of Civil Aerial Transport is to-day in a similar position to the question in 1830 of "Steam Communication with India," worked out for the East Indian Company by Thomas Love Peacock, assisted by Lardner.

The steamships were limited in size to the capacity of the port, and so these ports were forced to be as close together as possible: Falmouth, Gibraltar, Malta, Alexandria, Suez, Aden, and a final long stretch to Bombay. Peacock insisted in defiance of the Admiralty that the steamers should be made of iron, and took more pride in what he called his iron chickens than those works of fiction by which alone he is remembered to-day.

A PELTON WHEEL DRIVEN CENTRIFUGE.

By F. J. BROADBENT, M.Sc., Assoc.M.Inst.C.E.

IN ENGINEERING of September 11, 1914, a paper by the author appeared on "Some Static Torque Experiments on a Pelton Wheel." He there suggested that a satisfactory design of Pelton wheel could be obtained by a series of static torque experiments. The opportunity to put this theory to the test of experience was afforded by an inquiry to the firm of Messrs. Thomas Broadbent and Sons, Limited, Huddersfield, for a group of under-driven centrifugal machines for an explosives works, the motive power being hydraulic.

The author was entrusted with the work of designing a Pelton wheel at once efficient and economical to manufacture. The problem of design is essentially different for a Pelton wheel rotating on a vertical axis from that of one rotating in the

more usual way on a horizontal axis. In the latter case some form of the well-known double cupped bucket is always adopted and easily makes for high efficiency, but in the former case the adoption of double cupped bucket is a mistake because the part of the jet thrown upwards by the upper cup must fall on the rotating wheel and the oncoming jet; thus causing serious interference and loss of efficiency. The first principle of the design of a Pelton wheel rotating on a vertical axis is that the water discharged from the buckets must have a downward velocity as otherwise interference by the discharged water is unavoidable. There are two good practical ways of arriving at this result. First, the jet itself might be supplied with a downward velocity, thus first striking the buckets on their upward edges.

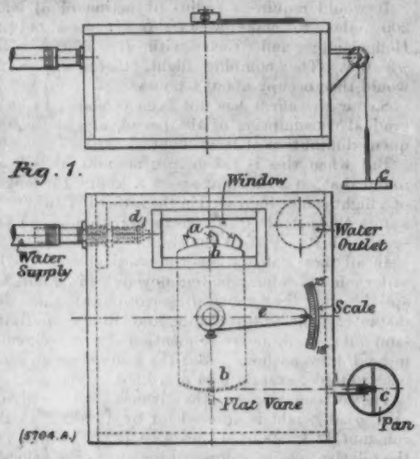


Fig. 1.

Second, the jet might be supplied horizontally, first striking the buckets at their outer edges near the tops and given the downward velocity by the shapes of the buckets themselves. After carefully considering these methods the author finally decided on the second because it appeared to him that it lent itself to an equally efficient wheel and a much simpler machine to manufacture.

For the particular machine required, a wheel 18 in. diameter appeared to be suitable. The author's previous experience showed clearly that the loss of efficiency in a Pelton wheel is more due to one bucket leaving and another coming under the jet than to any other cause. The minimum number of buckets which seemed to be suitable in this case, was 18, the pitch being 20 deg. Using this number three of the buckets were designed each with slight modifications. These were cut in wood (*a* in Fig. 1) and mounted on a wooden disc *b*, with a brass centre rotating on a vertical spindle. The disc was so arranged that the torque due to a jet playing on the buckets could be directly measured by means of a cord passing over a pulley and carrying a scale pan and weights *c*. A flat vane was also mounted on the disc for comparison, and an adjustable nozzle *d* was arranged to play a jet on the buckets. The disc and buckets were mounted in a box fitted with a window for observing the jet and an indicator *e* was attached to the disc for reading the angle turned through. Three buckets were used because the full static torque history of one bucket involves the leaving of the jet by the previous bucket and the entry by the succeeding one.

The first experiments made were very instructive. It was found that with 18 buckets there was a serious interference effect of the jet when the bucket was in the position of maximum striking. It did not appear possible to get rid of this without altering the bucket angles so much as seriously to reduce the efficiency. The original buckets were found also to be larger than necessary, but they showed clearly that in the best position the jet ran across and was discharged almost in the same form from the opposite bottom corner. It was also observed that when the jet had almost fully entered a bucket, part of it still being cut off by the edge of the bucket, a part of this jet was thrown outwards at a considerable angle, thus missing the preceding bucket altogether. This phenomenon was not entirely caused by bluntness of the cutting edge of the bucket, but was due to reactions in the jet itself when a portion of it was deflected by the bucket. A knife inserted in the jet gave the same effect.

As a result of a number of experiments the pitch of the buckets was altered to 18 deg., or 20 buckets in the complete wheel. Again, three buckets were made, each with slight modifications, and the best of these gave the form of torque variation shown on Fig. 2, where it will be observed that the torque was constant for more than 18 deg. out of the 20 deg. with the characteristic drops of torque on entry and leaving. The maximum torque for the flat vane was also measured. For comparison with the bucket torque a correction had to be made in the flat vane torque because in this case the effective line of action of the pressure is along the line of the oncoming jet, but in the case of the bucket it is somewhat nearer the centre of rotation as the jet is deflected towards this centre by the bucket.

The interference effect observed with the 18 buckets so that on the data now obtained the complete wheel was immediately put in hand, This was made of cast-iron in one single casting, and the only work on the buckets after cleaning out the sand was the grinding of their backs to make a sharp vertical edge where the jet first strikes them.

Fig. 3 is from a photograph of the complete wheel, together with a nozzle in the approximate position for working. Fig. 4 shows the completed centrifuge. A series of experiments were made on the completed machine. Fig. 5 shows the static torque graph. The characteristics of this are very similar to the wooden model, the difference being due to the higher velocities now used and the slight irregularities in the cast-iron. A series of brake horse-power readings were taken on the centrifuge. These were obtained by an ordinary absorption brake used on a special drum, which was fitted to the spindle of the centrifugal instead of the ordinary rotating cage, the latter being removed. The results obtained from two different-sized nozzles are shown on Fig. 6. In obtaining these results the method adopted was first to calculate the torque from the experiments, then to plot the graph for this and then to use the mean values as found from this graph for calculating and plotting the horse-powers. The reason for adopting this method is that the form of the torque graph is readily appreciated, and it is easier to plot a mean from this than from horse-powers calculated directly from the experiments. A series of acceleration tests were then made with the complete centrifuge, unloaded, the results being shown on Fig. 7. In these Graph A is for the smaller diameter of nozzle 0·286 in. Graph B is for a nozzle 0·296 in. diameter, but with the top of the outer casing removed. As will be seen from Fig. 4, this top projects over the lip of the rotating cage, and the effect of removing it is to allow a great quantity of air to escape at the top

Fig.2 STATIC TORQUE TEST ON EXPERIMENTAL BUCKET OF A PELTON WHEEL.

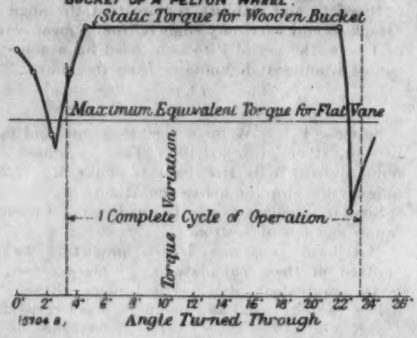
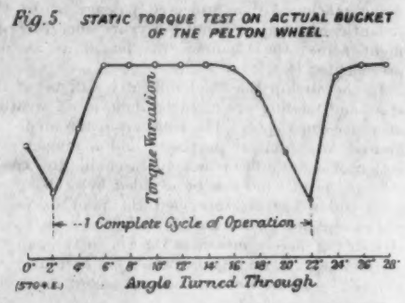

Static Torque for Wooden Bucket
Maximum Equivalent Torque for Flat Vane
Torque Variation
1 Complete Cycle of Operation
Torque
0° 2° 4° 6° 8° 10° 12° 14° 16° 18° 20° 22° 24° 26°
(5704 B.)
Angle Turned Through

Fig.5 STATIC TORQUE TEST ON ACTUAL BUCKET OF THE PELTON WHEEL.



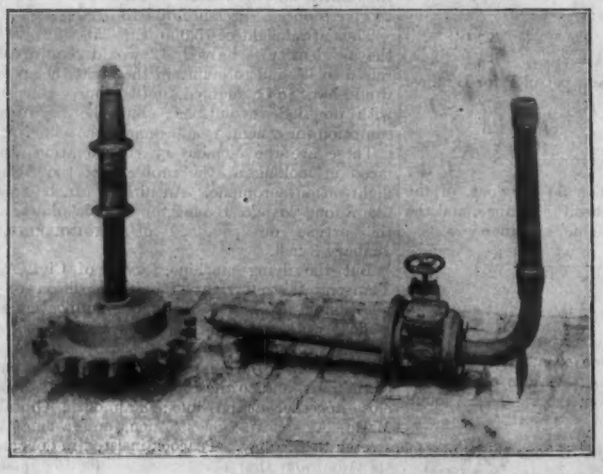


Fig. 3.

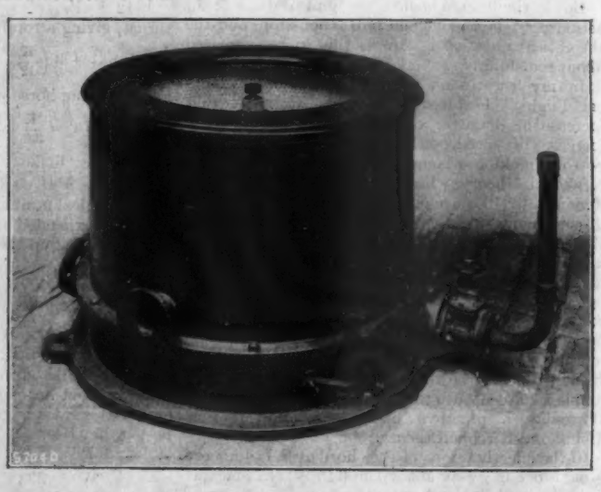


Fig. 4.

circumference of the centrifuge. The effect of this is shown clearly on graph B. The larger jet causes a more rapid acceleration at first than is the case for graph A, but afterwards, when the fan action becomes marked, the acceleration becomes less and the final velocity is 85 r.p.m. below that for the smaller jet. Graph C shows the acceleration for the unloaded cage under ordinary conditions, the top of the outer casing being replaced. It is there seen that a speed of 1,000 r.p.m. is obtained in 3·3 minutes, the maximum speed being 1,165 r.p.m. If a comparison is made between these results and the torque and horse-power graphs shown in Fig. 7 it will be seen that at the maximum speed the torque is only 0·25 of the starting torque and is falling, and that the horse-power has passed the maximum and is decreasing. Both these effects are good in centrifuges, the former because the acceleration period demands great initial torque if it is to take place within a reasonable time, and the latter because of the very stable conditions of running for bad loading of the cage, since an out-of-balance load will demand a greater horse-power, and this is available with only an inconsiderable reduction in speed.

Fig. 6. TORQUE & HORSE POWER GRAPHS, FOR PELTON WHEEL, FOR DRIVING A BROADBENT 42 INCH CENTRIFUGE.

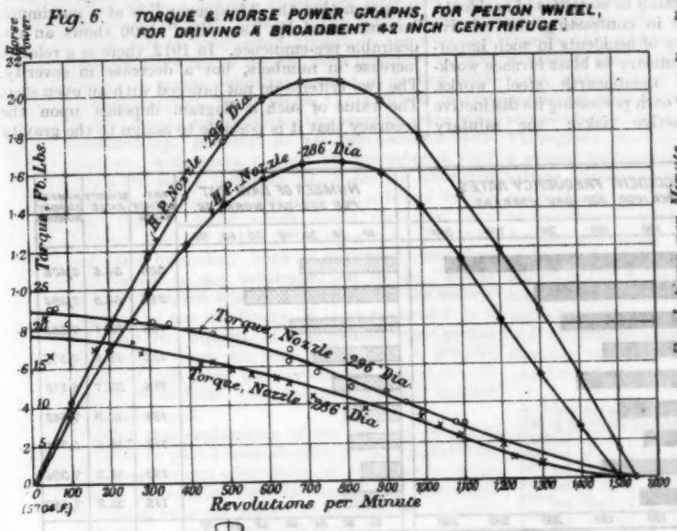


Fig. 7.

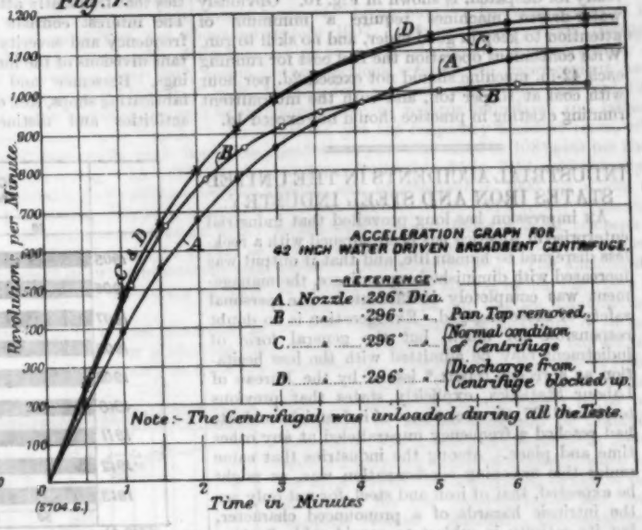

Revolutions per Minute
ACCELERATION GRAPH FOR 42 INCH WATER DRIVEN BROADBENT CENTRIFUGE.
—REFERENCE—
A. Nozzle .286" Dia.
B ... .296" ... Pan Top removed.
C ... .296" ... Normal condition of Centrifuge
D ... .296" ... Discharge from Centrifuge blocked up.
Note:- The Centrifugal was unloaded during all the Tests.
Time in Minutes
(5704 E.)

Fig. 8.

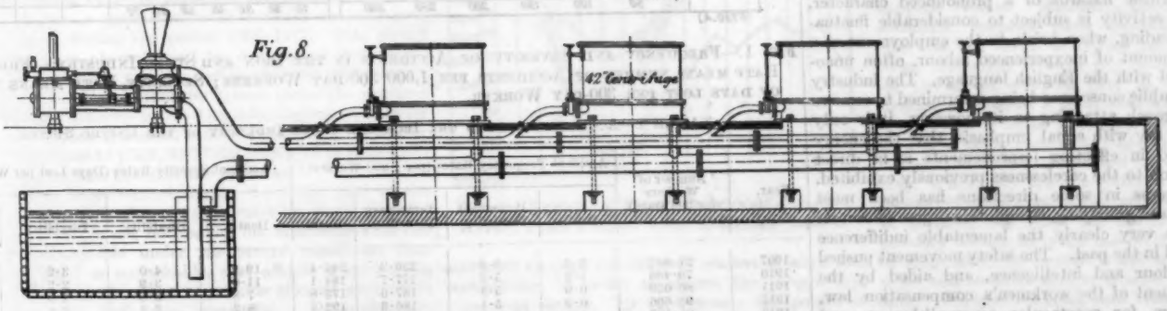


Fig. 9.

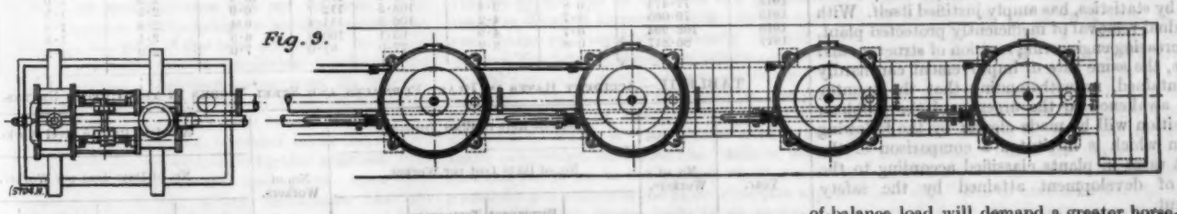


FIG. 10.

A very interesting point is shown by graph D. In this case the discharge opening for the liquid ejected from the cage was blocked up, thus stopping the discharge of air from this opening. The result was an increase of the maximum speed by 15 r.p.m. The increased acceleration became appreciable at just over 900 r.p.m.

It was anticipated from the original static torque experiments that about 5·5 lb. of water would be required per second. This proved to be too great an allowance, and the final amount used was only 4·75 lb. per second. The only alteration made from the original design was in the size of the jet, which was reduced slightly in diameter.

Turning now to the design itself; the centrifuge is a bolted-down under-driven machine of the well-known substantial type manufactured by Messrs. T. Broadbent and Sons, Limited, fitted with four sets of ball bearings and with a foot brake. The Pelton wheel is in a separate lower chamber, and the position of the nozzle is absolutely fixed by being fitted to a turned cast-iron pipe which passes through a bracket accurately bored to receive it and cast solidly with the bottom of the Pelton wheel chamber. As this work was made to jigs after the best position of the nozzle had been found by experiments, the whole was at once rigid, accurate and economical.

Machines of this character are admirably adapted

for situations where a battery of machines is required especially under the trying conditions existing in certain chemical and explosive works which give a great deal of trouble to any electrical apparatus. Such a battery is shown in Figs. 8 and 9. A group of four machines as actually manufactured, and ready for despatch, is shown in Fig. 10. Obviously water-driven machines require a minimum of attention to keep in good order, and no skill to run. With continuous operation the fuel cost for running each 42-in. machine should not exceed 2*d.* per hour with coal at 1*l.* per ton, and with the intermittent running existing in practice should not exceed 1*d.*

INDUSTRIAL ACCIDENTS IN THE UNITED STATES IRON AND STEEL INDUSTRY.

An impression has long prevailed that industrial enterprise in America has been pursued with a reckless disregard to human life, and that if output was increased with diminished expenditure, the management was completely indifferent to the personal safety of those engaged. Exaggeration is no doubt responsible for much, but the general form of indictment may be admitted with the less hesitation as a recent report,* issued by the Bureau of Labour Statistics, explicitly states that previous to about 1907, the occurrence of industrial accidents had reached a frequency unparalleled at any other time and place. Among the industries that came under this sweeping condemnation was, as might be expected, that of iron and steel, for not only are the intrinsic hazards of a pronounced character, but its activity is subject to considerable fluctuations, leading, when brisk, to the employment of a large amount of inexperienced labour, often unacquainted with the English language. The industry or the public conscience being determined to remove the reproach attaching to it, however, it is only right to say with equal emphasis, that the energy displayed in effecting improvements is in direct proportion to the carelessness previously exhibited. The success in some directions has been most marked and gratifying, though this degree of success indicates very clearly the lamentable indifference tolerated in the past. The safety movement pushed with ardour and intelligence, and aided by the development of the workmen's compensation law, had room for spectacular accomplishment, and judged by statistics, has amply justified itself. With the gradual removal of inefficiently protected plant, with increasing engineering revision of structure and practice, the same rate of improvement can hardly be maintained, notwithstanding that the country is fully awakened to the urgency of the problem. The position will be made clearer by the following table, in which is instituted a comparison of the accident rates in plants classified according to the degree of development attained by the safety movement.

Class.	Number of Day Workers.	Number of Accidents.	Accident Frequency, Rates per 1,000 Workers.
Previous to development	14·916	7·576	507·9
Early days of development	18·830	7·852	272·4
System well developed	24·411	4·079	167·1

The improvement shown in the last column is apparently phenomenal, but we have to take into account that the situation in the early part of the century had become intolerable. Those who have witnessed what has been effected in a short period, look forward to the day when industrial accidents will be completely eliminated. "It is possible," say the authors, "to conceive industry conducted under conditions so safe, that the occurrence of severe injury will excite the same surprise that its absence now does." The goal set is a worthy one, and without sharing in the Utopian belief, we may gratefully acknowledge the progress of the organisation, the thoroughness of the method employed and its happy results.

The analysis of the figures, which has been made on a much larger scale than indicated in the above table, will prove both interesting and salutary, if the analysis is thorough, and avoids the ambiguities that frequently attach to statistics of accidents. The interest consists in contrasting the relative frequency and severity of accidents in such important divisions of the industry as blast furnace workings, Bessemer and open-hearth steel works, fabricating shops, &c., each possessing its distinctive activities and distinctive risks; the salutary features in tracing the causes of accidents to their source and discovering how far neglect of proper precautions has contributed to the result, with the view of taking the necessary steps for removing hazardous conditions.

It is evident that an accident can only be defined by convention, and when the range of disablement is necessarily wide, some further device is necessary to classify degrees of severity. The Labour Bureau treats as an accident an injury arising out of employment and resulting in such disability as to cause a greater loss of working time than the remainder of the day or shift in which the injury is incurred. The precise definition is of less importance than the observance of the same definition throughout a group of trades. If such a definition is generally recognised, the return of the number of accidents will be accurate, but it will make no estimate of the severity of the resulting injuries. The economic significance between an accident which bruises a workman's thumb and one by which he loses his life, demands careful consideration.

In the following diagram, Fig. 1, an attempt is made to contrast frequency with severity. In 1905, it is seen that the "frequency" is at a maximum, but measured by "severity," 1906 shows an undesirable pre-eminence. In 1912, there is a relative increase in numbers, but a decrease in severity. The two criteria do not proceed with an even step, The value of such a diagram depends upon the accuracy that it is possible to assign to the gravity of each accident. The basis for determining the "severity" rate is the number of lost working days the accident occasions the injured man. The exact equivalent in working days for fatal or permanent injuries, as well as for temporary disablement, cannot be determined, but in the Report it is estimated that the working time lost to the community in case of a fatality is equal to the loss of 30 years working time of 300 days, or 9,000 days; the loss of an arm is reckoned at 2,808 days, a foot at 1,845 days, and, similarly, estimates are made for injury to other members. A total disability to work is regarded as a greater loss to the industry than a death, because the incapacitated man has to be supported at the public expense. On this ground, the time-loss for permanent total disability is put as high as 10,500 days. This method of evaluating injury in terms of time-loss, although necessarily based on rough estimates, is not entirely

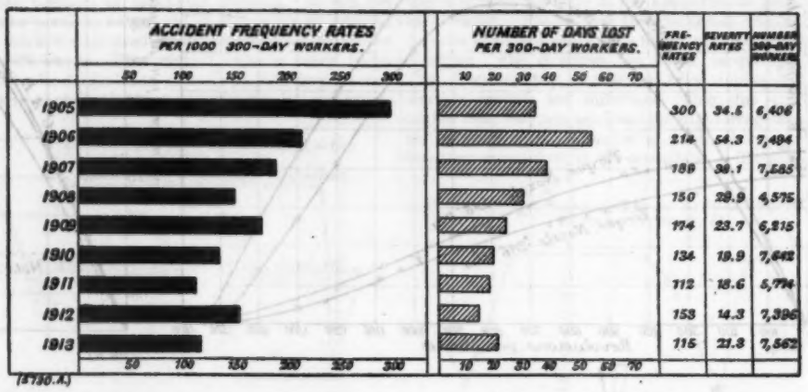


Fig. 1.—Frequency and Severity of Accidents in the Iron and Steel Industry.—Frequency Rate means number of Accidents per 1,000 300-day Workers; Severity Rate means number of days lost per 300-day Worker.

TABLE I.—Accident Rates in the Iron and Steel Industry of the United States.

Year.	Number of Workers (for 300 Days).	Accident Frequency Rates (per 1,000 Workers).				Accident Severity Rates (Days Lost per Worker).			
		Death.	Permanent Disability.	Temporary Disability.	Total.	Death.	Permanent Disability.	Temporary Disability.	Total.
1907	27·632	2·2	3·8	236·3	242·4	19·9	4·0	3·2	27·1
1910	79·486	1·2	5·2	177·7	184·1	11·0	3·9	2·2	17·1
1911	80·029	0·9	5·3	167·6	173·8	7·8	3·8	1·9	13·5
1912	93·666	0·9	5·1	186·3	192·3	8·2	3·4	2·2	13·8
1913	91·107	1·1	4·5	150·3	155·9	10·3	2·9	1·9	15·1
1914	77·474	0·8	3·4	108·5	112·7	6·9	2·5	1·5	10·9
1915	79·065	0·7	4·2	106·5	111·4	6·4	2·6	1·3	10·3
1916	108·994	0·7	4·9	95·1	100·8	6·3	3·1	1·3	10·7
1917	86·847	0·8	3·2	77·0	81·0	7·0	2·0	1·2	10·2

TABLE II.—Accident Rates in Blast Furnaces and Steel Works in the United States.

Year.	Accident Rate in Blast Furnaces.					Accident Rate in Steel Works.				
	No. of Workers.	No. of Days Lost per Worker.				No. of Workers.	No. of Days Lost per Worker.			
		Death.	Permanent Disability	Temporary Disability.	Total.		Death.	Permanent Disability.	Temporary Disability.	Total.
1907	961	51·7	6·9	5·5	64·1	1,176	30·6	13·7	5·5	49·8
1910	3,891	25·4	2·3	2·8	30·5	4,246	38·2	6·5	3·2	47·9
1911	3,921	16·1	8·0	2·3	26·4	4,293	14·7	4·4	2·3	21·4
1912	5,034	26·8	6·4	2·8	36·0	5,546	19·5	4·7	3·1	27·3
1913	5,641	24·0	5·1	2·3	31·4	5,207	13·8	3·7	3·1	20·6
1914	4,797	20·6	3·8	1·7	26·1	3,073	20·5	3·3	2·1	25·9
1915	4,835	22·3	2·7	1·3	26·3	4,713	11·5	4·6	1·6	17·7
1916	6,694	12·1	10·9	1·5	18·5	6,556	13·7	6·3	1·8	21·8
1917	5,194	31·4	1·9	1·1	34·4	6,347	14·2	1·9	1·4	17·5

* "*The Safety Movement in the Iron and Steel Industry,*" *1907–1917.* By Lucian W. Chaney and Hugh S. Hanna. Bulletin No. 234 of the United States Bureau of Labour Statistics. Washington: Government Printing Office. [Price 25 cents.]

arbitrary. The method is sound, though objection may be taken to details. Of course, it is possible in a severe mining accident, or in the lamentable disasters due to explosions that this country has had to mourn during the war, that in the case of some particular establishment, the severity rate might show a greater number of days lost than the plant actually worked. The result, however, would still be intelligible, though in the iron and steel industry under review, such instances do not occur. A graver objection is, that in dealing with a comparatively small plant, the addition of one or two deaths will influence the severity rates very considerably, possibly in an unreasonable proportion. And, again, it must be remembered, that there are many accidents which are not attended by personal injuries. For instance, a heavy weight falls from a crane which would certainly have crushed a man if it had fallen upon him. The man is missed by inches. Such an untoward event does not appear in any catalogue, but to the "safety man," the agent who is responsible for the orderly working of the machinery, it is as important as if the man were injured. It is an evidence that proper precautions have not been taken, that a possible cause of injury has been overlooked, and it is only by an "accident" that the severity rate has not been increased.

With this explanation of the severity rate it is possible to pass a more discriminating judgment on the improvement effected by the introduction of the safety movement, and incidentally of the effect produced by grave industrial fluctuations. For this purpose, a general view of accident rates is presented, during the period 1907–1917. This period has been characterised by commercial depression, and, owing to the war, by an activity without precedent. The demand for labour under the pressure of this activity led to the introduction of entirely new labour elements, and to a movement of labour from place to place, and from employer to employer, such as had never before occurred.

The improvement during the latter part of the time, as judged by severity rates the more accurate criterion, is not noticeable, but that no sudden rise is perceptible under the severe conditions that obtained is remarkable, and affords a convincing proof that the effort to provide efficient preventive measures had been successful. Naturally, the diminished accident rate was not uniform. "In some branches of the industry accident rates kept declining in spite of the new pressure. In others, however, there was a condition bordering on demoralisation. Accident rates went up rapidly. By the middle or latter part of 1916, the situation almost everywhere was well in hand."

Table I, on page 164, contains many instructive facts which can be elicited by further analysis. The diminution of accidents consequent upon the development of the safety movement has not proceeded uniformly in all departments, and it is possible for the good results in one branch to be negatived or masked by indifferent working in another. The inequality of numbers employed in different divisions of the industry has also a disturbing effect, and the nature of the employment calls for further investigation. An example will best illustrate the need for examination, and further will serve to contrast the relative risks encountered in certain main departments; in this case the hazards incurred in blast furnaces are compared with those of Bessemer and open-hearth steel works (see Table II, page 164). The accident severity rate being as explained above, equally applicable to both classes, will furnish the best guide to the hazards inherent in the industry and to the improvements effected by care and prevision.

The figures for the year 1917 are swollen by the effects of a few fatal accidents among blast-furnace workers, illustrating the manner in which irregularities can be introduced into the statistics by the plan of assigning numerical equivalents to a few severe casualties. A great improvement appears to have been effected immediately after 1907, and since that time, though care and attention have not relaxed, little impression has been made. It is only right to add, however, that in the feverish days of 1916, when the industry called for a large accession of new men, there was no corresponding increase in the number of accidents. In other words, the countervailing influences of the preventive system were competent to meet the unprecedented stress of war work. Another superficial conclusion from the table is that the hazards in steel works are considerably less than among blast-furnace workers. The accident rates in steel mills, tube mills, rolling mills and other special departments, though the number of casualties per thousand workers is less, all show the same order of fluctuations, a sharp drop in severity after 1907, accompanied by more or less pronounced "peaks" in the representative curve, when industry becomes brisk. Throughout the whole series these "peaks" show a general tendency to flatten, each peak being less salient than the one preceding. In 1914, at the outbreak of war, industrial activity fell to a low ebb, to be followed by a period of employment increased beyond precedent. The consequence was an influx of inexperienced hands that give rise to peaks, as shown in Fig. 2. Although in 1917 employment was still rising, fatalities remained stationary or were actually falling.

If experience gained is to be turned to account in devising more effective methods for protecting life and limb, further analysis is necessary to trace the

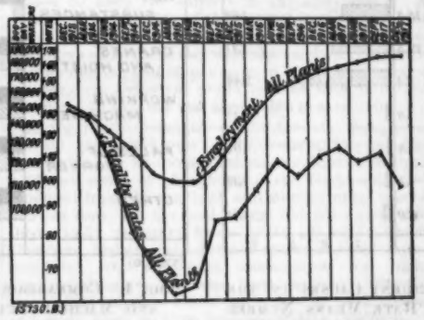


FIG. 2.—TREND OF EMPLOYMENT AND FATALITY RATES, YEAR ENDING WITH SPECIFIED MONTH.

accidents through the different classes of work and occupations, in order to detect the origin and sources of danger. By such means the points of greatest hazard can be detected and precautionary measures directed to precise ends. In the iron and steel industry, employing nearly 200,000 day workers, the total of accidents can be conveniently divided into the eleven classes shown in Fig. 3, page 166. There will always remain one class in which the cause of the accident is unknown or unreported. Each of the classes named can be again subdivided, and from the "falls of workers," for example, it can be determined whether a ladder, a scaffold or a vehicle is the more uncertain support, or whether more danger lurks in an excavation or an unguarded opening. These are niceties of discrimination into which it is not necessary to follow the authors. They do show, however, the thorough sifting to which the statistics have been submitted, and the amount of accurate information placed at the command of the department. Before leaving the statistics of numbers and severity, it is well to compare the relative hazards in the iron and steel industry with those of some other trade as machine, building, in which six of the divisions or groups are common to both. Such a comparison is best made graphically by means of a chart, as shown in Fig. 4, page 166. As might be expected, machine building has lower rates generally, but since machine building plants are presumably machine using, the number of injuries from the working of machines is greater in the case of machine building.

In four interesting chapters the authors discuss the causes of accidents in the more prominent departments of blast furnaces, steel works and foundries, rolling mills and, finally, in the mechanical, fabricating and transportation operations. Blast furnaces may be selected as characteristic of the treatment applied to the whole, and as typical of what has been, and what may be, effected by promoting greater freedom from accidents. As a general rule, it is gratifying to note, that though some operations are naturally much more sensitive to fluctuating industrial conditions than others, all have been favourably influenced by preventive methods during the period under review. The main causes of injuries have been "break outs," explosions connected with "slips," gas flames, and asphyxiating gases. Improved construction can control some of these operating causes, as in the case of "break outs," a frequent source of trouble before 1907, that has now entirely disappeared, owing to increased strength of construction. In the other sections referred to, improvement has been hardly less marked. The years 1906 and 1913 are comparable as regards industrial and labour conditions, yet the frequency accident rates, which in the former year amounted to 108 cases per thousand workers, declined to 26 in 1913, and severity rates, which are represented in 1906 by a loss of 60·8 days per worker, fell in 1913 to 19. This improvement, which is manifestly a great triumph for all concerned, is mainly due to the introduction of suitable protecting devices. The authors describe and illustrate some special forms, but there is little reason to quote, as our English manufacturers are no whit behind, either in ingenuity or in readiness to adopt safeguards adapted to our methods of manufacture. For instance, the evils of sparks and splashes occasioned by the drawing off of the cinder from the cinder notch are shown to be rendered innocuous by shields that can be lowered when necessary. The drawing of the metal at the tapping hole is a frequent source of accident, when operated by man power. An air-drilling device is now substituted for the hand-operated bar, with the happiest results. Similarly, the employment of automatic couplers when connecting ladle cars, after the hot metal or cinder has been placed in them, materially reduces the chances of accident, for the metal slopping over at the moment of striking introduced a great risk when the coupling was effected by hand. The explosions due to "slips" are not so easily remedied. These depend in a great measure on the character and manipulation of the ores. When these are of a granular structure, a free passage of gases towards the furnace top can usually be secured, but when the ore is of an earthy, powdery nature, as is the case with the Mesaba ore of Minnesota, the burden is apt to become impervious and threaten serious trouble to blast-furnace men. Without entering into technical details, it may be said that this impervious burden is liable to be checked in its downward movement, while the steady burning of the fuel below gradually removes the support. Then, suddenly, the obstruction is overcome by the weight of the superincumbent material, and the iron burden drops down to a new level. Since this falling mass may be 20 ft. in diameter and 60 ft. high, the mechanical effect is tremendous. Cases are quoted in which as many as 14 men lost their lives in an explosion following a "slip," and in another case, the whole stack was wrecked by the disastrous explosion, and 12 men were killed. The maintenance of uniformity of size in the material supplied to the furnace, and a reduction in the number of hand-filled furnaces, with, consequently, a smaller number of top fillers, have contributed much to the successful results already quoted. The hazard of "gas flames" can be considerably diminished by the practice of washing the gas. Great quantities of dust-laden gas are easily caught by appropriate means, and the current being compelled to move more slowly, the deposit of the heavier particles results. The more impalpable portion, however, passes on, and when fed directly to the stove, may choke the openings between the checker bricks and cause flames to burst out at unexpected places. In improved plants, the gas is passed through a washer, where the dust is caught by water sprays, and the gas passes perfectly clean. Not only is the operation made safer, but the firing is more efficient. The collections of asphyxiating gas are more insidious and difficult to trace. A lurking source of danger has been traced to leakage from gas mains when placed underground, causing accumulations in some enclosed place. The substitution of overhead mains has done something to reduce this evil, but the application of an efficient remedy has still to be framed. This is shown by the refusal of the frequency and the severity rates to exhibit the same marked

improvement which has characterised the other causes of injuries. From 1905 to 1909, the severity rate was 15·4 days per worker; in the next five years the rate dropped 50 per cent., but in 1914, the severity rate was 15·5 days, or as high as in 1906.

The Bessemer steel works, rolling mills and sheet mills, have each their own special dangers, but the examples given will serve to show the method upon which the department has worked. It is an eminently safe and scientific method; the statistical curve is developed in order to trace the origin and relations of casualties, to detect the hazards peculiar to any

The want of necessary training to give the worker control and caution is shown by the decrease in the number of accidents with increased length of service. In the case of a large plant, it was found that those of under six months' employment were sufferers in 57 accidents. From six months' to one year's service, the number was halved, and as experience increased, the number of accidents diminished regularly, till among those who had served over 15 years, there were no recorded injuries, though the number employed in this last class was nearly as large as those who had been in the firm less than six months.

maturity and skill, would probably operate in the same way as inexperience in recruits, but less in degree. Practically, it is not possible to trace any effect as defintiely due to this cause. Similarly, there is no measureable difference between the accident frequency rates of the married and unmarried of the same age groups. The effect of alcohol is more debateable, those who are in contact with the men are practically unanimous in expressing the conviction that the excessive use of alcohol is an important factor in causing accidents, but unimpressionable statistics by no means speak so clearly. It is impossible to get the same direct evidence that is easily

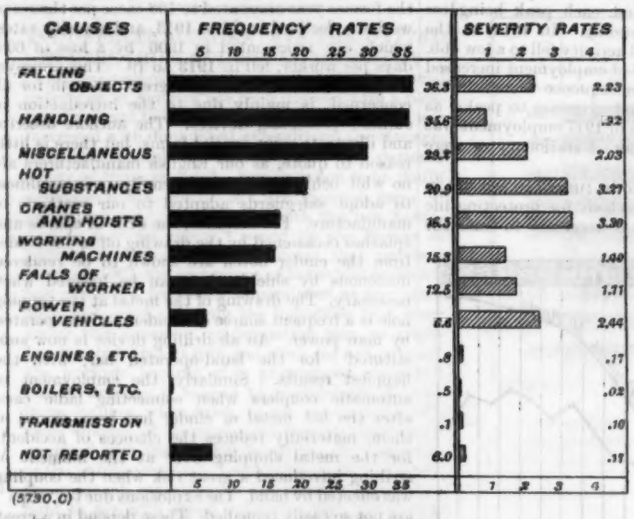


FIG. 3.—ACCIDENT RATES FOR PRINCIPAL ACCIDENT CAUSES IN THE IRON AND STEEL INDUSTRY. [FREQUENCY RATE MEANS NUMBER OF ACCIDENTS PER 1,000 300-DAY WORKERS.; SEVERITY RATE MEANS NUMBER OF DAYS LOST PER 300-DAY WORKER.]

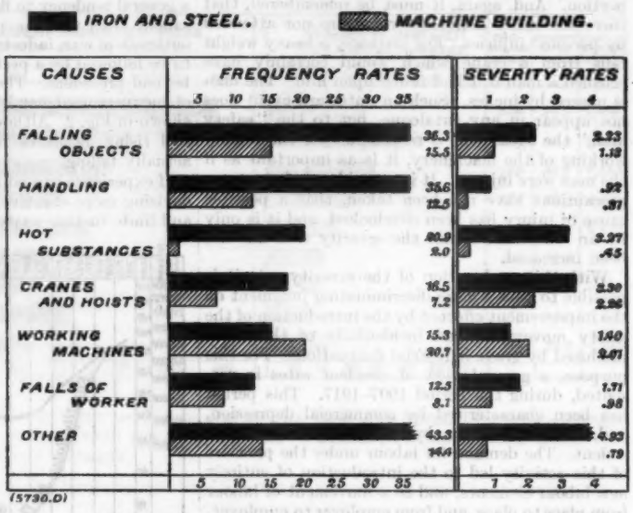


FIG. 4.—COMPARISON OF ACCIDENT CAUSES IN THE IRON AND STEEL AND MACHINE BUILDING INDUSTRIES. [FREQUENCY RATE MEANS NUMBER OF ACCIDENTS PER 1,000 300-DAY WORKERS; SEVERITY RATE MEANS NUMBER OF DAYS LOST PER 300-DAY WORKER.]

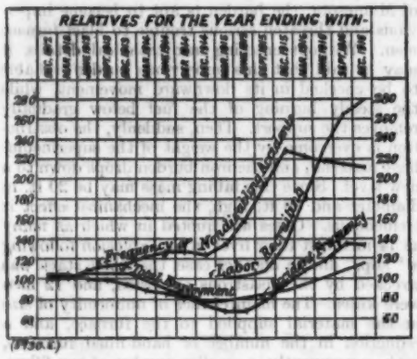


FIG. 5.—RELATION OF LABOUR RECRUITING, EMPLOYMENT, AND OUTPUT TO ACCIDENT OCCURRENCE, 1912 TO 1916, PLANT C.

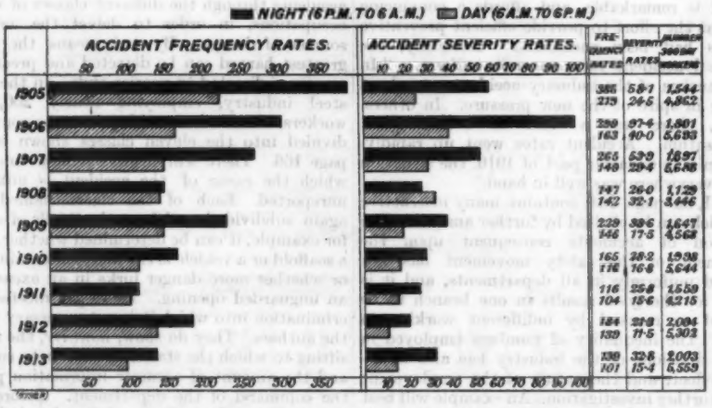


FIG. 6.—NIGHT AND DAY RATES IN A LARGE STEEL PLANT, BY YEARS.—FREQUENCY RATE MEANS NUMBER OF ACCIDENTS PER 1,000 300-DAY WORKERS; SEVERITY RATE MEANS NUMBER OF DAYS LOST PER 300-DAY WORKER.

branch occupation, and when the evil stands manifest, to devise improved machinery that will eliminate the risks. No source of injury is overlooked, but without the assistance provided by careful analysis, it is possible that undue attention would be paid to the more glaring instances.

Industrial accidents are not confined solely to physical causes. Besides the machine, the structure, the handled product, the worker himself is to be regarded as a contributory factor in accident occurrence. Dispassionate inquiry shows, however, that more blame has been attached to the human element than is fitting. Inexperience and lack of training account for many accidents, night work under unfavourable conditions of illumination is also responsible for swelled rates, and the same may be said of the effects of heat and cold on the worker. But, usually, when investigation is probed far enough, it is found that some defect in machinery or some injudicious method of operation has been a contributing cause, notwithstanding the action of the operative.

The influence of "labour recruiting," which implies the acceptance of untrained men, is clearly declared in Fig. 5. The parallelism of the curve of non-disabling accidents, that is, the kind of accident to which a novice is peculiarly liable, with that of labour recruiting, is pronounced, till the end of 1915. At that date the management insisted on the establishment of special systems of control. The efficiency of the method in promoting improvement is as striking as the increase of occurrence, for though the recruiting continued, the accidents diminished. The curve of general accident frequency was below that of total employment, till the introduction of untrained men gave rise to an upward tendency. Improved supervision did not make itself apparent so early in this curve as in that representing non-disabling accidents.

The age of workers, implying various degrees of

collected in the case of physical causes. When a man is run down by a car, that fact can be determined and recorded. It is a very different matter to determine whether alcohol had much or little, or nothing to do with failure to escape from his dangerous position. There is, however, one fact that is significant. The data indicate a very decided tendency to higher accident rates at night. This is shown in Fig. 6. The accident rates between 6 p.m. and 6 a.m., shown in heavy black, whether judged by number of severity, everywhere overlap the shaded lines that represent the accidents between 6 a.m. and 6 p.m. The authors draw the obvious conclusion, either the results are due to (1) imperfect lighting, or (2) "an unsatisfactory condition of the worker due to various causes." Some further light is thrown on this verdict by examining, where such records are kept, the offences against discipline as

shown by conviction for the use of intoxicants. It is then found that the rates for the night turn are much in excess of those for the day.

The distribution of accidents throughout the working days opens, apparently, an interesting study, for it might reasonably be expected that the effects of fatigue on the worker would be disclosed. Other inseparable factors, however, enter to such a degree, that the effect of fatigue, if existing, is completely masked. Fatigue cannot be distinctly recognised as an operating cause in any of the curves that have been drawn. The characteristic form of distribution is shown in Fig. 7 subjoined, from which it may be inferred (1) that there are a greater number of accidents in the morning than in the afternoon; (2) that there are peaks of frequency at 10 a.m. and 3 p.m.; and (3) a gradual rise to and decline from these high points. Production, it will be observed, shows an uniform

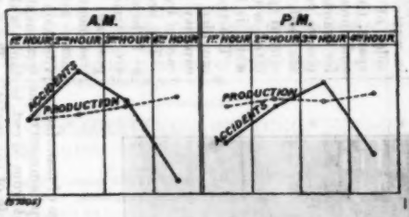


FIG. 7.—ACCIDENTS AND PRODUCTION AMONG PRESS HANDS.

tendency to increase throughout the forenoon, but is maintained with some irregularities later in the day. The general result is surprising, not to say, anomalous. Product is seen to be rising and accidents responding for a while, but later, with still rising product, accidents decidedly diminish. The authors suggest that at the outset of any effort, there is a certain lack of harmony between the will and the nervous and muscular agents by which results are attained. It is not without significance, that Professor Stanley Kent has called attention to a parallel result, in what he terms "the Monday effect in industry." Professor Kent ascribes the cause of inefficient work on Monday and the first working period of any day, "to abstention from work, resulting in operations which are ordinarily performed quickly and well, being to some extent forgotten, and to that extent having to be relearnt before the old efficiency can be regained."

To pursue the subject further would be to substitute the doubtful realm of trade psychology for the sure ground of rigid statistics, that has hitherto informed us. We will, therefore, only offer our congratulations on the success which has attended the efforts of many earnest workers in this path of true human progress. We all know how the sense of satisfaction arising from successful labour can numb the enthusiasm of the most devoted, who are liable to become weary of well doing, and, therefore we note with pleasure the schemes devised with the view of keeping alive a keen interest in the work, and the plans of co-operation that aim at the extension of the safety movement.

FERRO-ALLOYS BY ORE SMELTING IN ELECTRIC FURNACES.

WHEN the war broke out in 1914, the only commercial electric furnace plant in the United States west of the Mississippi was a pig-iron works in California. Concentrates of the rare metals were sent to the east for reduction. Now there are two electric ore smelters in California, one in Washington, one in Iowa, four in Colorado, and three more under construction in California and Montana. The four Colorado works are those of the Tungsten Products Company and of the Boulder Tungsten Production Company, both of Boulder, and the Ferro-Alloy Company and the Iron Mountain Alloy Company, of Utah Junction; all these works receive current from the Colorado Power Company; their respective capacities are 800 kw., 400 kw., 1,200 kw., 3,000 kw., and they all make ferro-alloy. The two last-mentioned companies are under the management of Mr. Robert M. Keeney, who communicated some very interesting particulars of their smelting work to the meeting of the American Institute of Mining Engineers last September.

The Ferro-Alloy Company has installed one three-phase furnace of 750 kw., fed by three transformers of 250 kw. coupled Δ to γ to give 129 volts on the furnace cables, and one 450-kw. furnace, only apparently three-phase, fed by three independent single-phase transformers. Both the furnaces are of the same size, consisting of a steel shell 8ft. deep and 7ft. diameter, lined with magnetite; the first furnace is provided with three vertical carbon electrodes, 12 in. diameter, the second with three 8-in. carbons and a carbon bottom; the electrodes were always regulated by hand. The Iron Mountain Alloy Company smelts in two three-phase furnaces, one of 1,200 kw., the other of 1,800 kw., with the aid of single-phase transformers coupled Δ to Δ; the shells are 18 ft. long, 8 ft. wide and 7 ft. deep; the electrode diameters are 17 in. and 24 in. Ferrochrome is made from domestic chromite ore which contains from 40 per cent. to 50 per cent. of Cr_2O_3 and more iron than the imported ores contain. Mr. Keeney did not describe his furnaces; but he gave full analytical data and particulars of the charges. A 6 per cent. carbon alloy, it was found, could be produced without any flux, more easily than a lower carbon alloy; but the slag was thick and carried a good deal of chromium; the chromium recovery was better when lime was added to the charge; the further addition of sand did not improve the metal recovery, but helped to keep the sulphur in the alloy down. A natural flux consisting of the mineral in the ore and of the coke ash seemed to answer best on the whole. Low-grade ores and chrome slag were also smelted. The ferro-chrome obtained, of 60 per cent. to 67 per cent., was a few per cent. below the grade realised with imported ore (65 to 70 Cr), but was acceptable to steel refiners.

As regards ferromanganese, the domestic manganese dioxide ores used were dusty, causing loss in the electric furnace, and some of them contained as much as 0.55 per cent. of phosphorus; the ferromanganese produced from the ore, coal, and steel turnings was of 0.2 per cent. P; the coal charge did not exceed the theoretically necessary figure by 10 per cent., whilst elsewhere higher coal excesses are considered indispensable; the electrodes consumption was high. Ferromolybdenum has also been prepared, directly from crude sulphide mixed with lime, or with silicon and some lime, or from lead molybdate (wulfenite); the latter is first smelted with soda ash and coal to produce lead bullion and sodium molybdate, the molybdate then being reduced with coal in the electric furnace; this last reduction required more power than the others. A fairly good ferromolybdenum with 60 per cent. to 66 per cent. of Mo, 1 per cent. to 2 per cent. of C, less than 0.1 per cent. of S and 1.1 per cent. of As' was obtained. There is still a prejudice against the use of ferromolybdenum in the steel industry among American metallurgists. No particular difficulty was experienced in making ferrotungsten from local ferberite which contains tungsten and iron (together with a little manganese) in proportions to yield an alloy of 70 per cent. or 80 per cent. W. Ferrovanadium was obtained from roscoelite, which is a complex silicate of vanadium and aluminium resembling mica; the ore contained up to 3 per cent. of V_2O_5. The ore is first roasted with salt and pyrite, the sodium vanadate produced is extracted with hot water, and the solution precipitated with iron sulphate, air being passed through the solution in order to obtain iron vanadate or vanadium oxide. The subsequent reduction of the oxide is effected with the aid of silicon or aluminium, as carbon would yield carbide. The company melts steel turnings in the electric furnace, adds the oxide and then silicon (aluminium proved more expensive) and lime in portions; when iron vanadate was used, steel turnings were not required. The ferrovanadium produced (30 per cent. or 36 per cent. V, 4 per cent. Si) has to be refined in the electric furnace with a slag of vanadium oxide, lime and fluorspar to eliminate the silicon so far as possible; this operation increased the carbon content to 1.5 per cent. (from the electrodes) and the removal of this carbon could only be effected with a loss of some vanadium which passed into the slag.

With respect to the last alloy prepared, ferro-uranium, we would refer our readers to our article under this heading in our issue of January 11, 1918, pages 41 and 42. The experiments by Keeney were made with the sodium uranate $Na_2U_2O_7$, a by-product of the radium production. The reduction of the oxide, also tried, was commercially a failure; it was not possible to keep the carbon low without wasting uranium, and the production of uranium metal at high temperatures in a Siemens electric furnace by means of petroleum coke was not satisfactory either, the metal containing both oxide and carbide, and the losses of uranium were heavy. The paper gives an account of many varied experiments, however, also on the preparation of ferro-uranium, and on the use of this alloy and of uranium metal in the steel industry; some of these latter experiments were made by the Braeburn Steel Company, Pennsylvania.

Summing up, it should be pointed out that, though we have spoken of experiments, most of the data have been drawn from commercial operations. Ferro-alloys to be utilised in the steel industry should be low in sulphur and phosphorus and other impurities, and low also in carbon. It is much easier, and much less expensive, however, in most cases to produce a high-carbon alloy, and these alloys have the one advantage of a relatively low melting-point and can hence be added to steel baths of ordinary temperature. The high-carbon percentage is inadmissible for other reasons, of course. Low-carbon alloys can be produced by three methods: (1) The ore may be smelted with an excess of carbon and a small slag-loss; the high-carbon alloy produced is then broken up and refined with oxidising slag; (2) the ore may be smelted with the theoretical amount of carbon to produce a 1 per cent. C alloy which does not require refining, but the slag loss will be high; (3) the ore may be reduced by silicon or aluminium, with small slag loss, the excess of these agents being subsequently removed by refining with an oxidising slag.

COAL IN GERMANY.—Large increases in prices have been found necessary, both in the coal mining and iron and steel industry. The price for coal has been raised 12 marks and for coke 18 marks per ton, added to which comes the tax, 20 per cent. in both cases. It has also been decided to reduce the production of coke by 50 per cent., owing to the temporary lack of means of transport to the south-western German industrial districts. In addition, it has been found necessary to discontinue the working of a number of coke ovens which had to a great extent been run by prisoners of war principally Russian, who now, if still in the district generally refuse to work. A third reason for the reduced coke production is to be found in the fact that several kinds of coal, hitherto used for coking purposes, are now put to other uses. The Berlin Chamber of Commerce has excellent statistics bearing upon the production and rise of wages in the coal mining industry. The wage of the Upper Silesian hewers was before the war 9 marks for an average working shift of 9 hours. During the war it was raised to 13 marks, whilst the output per man and shift receded from 1·2 tons to 0·85 ton. At the beginning of November the men demanded 18·4 marks for an 8 hours' shift, besides gratuities. The production per man fell to the exceptionally low average of 0·75 ton. Thus the charge per ton of coal as regards the hewer alone had risen from 7·50 marks to 24·50 marks. This has necessitated a rise in prices from January 1 of at least 10 marks per ton, which, reckoned on a production of 250,000,000 tons per annum and with the 20 per cent. coal tax, means a very heavy annual extra charge to the German nation. Higher coal prices always mean higher iron prices, and these latter have already been increased to an unprecedented degree. The aggregate monthly wages has risen from a little over 1,000,000,000 marks to more than 3,000,000,000 marks.

CALENDAR REFORM.—Though the Gregorian calendar has in quite recent years been adopted not only in the east and south-east of Europe, where they were 13 days in arrear, but also in Japan and China, enthusiasts like G. Bigourdan renew their proposals to improve the Gregorian, possibly because so many things are now being reformed, or ought to be. The chief objection to the Gregorian calendar is that the dates of the month do not concord with the days of the week. That the year is a little too long, and that the year 4000, which ought to be a leap year according to the general rule, will have to be satisfied with 365 days, need not worry the present generation; as the length of the tropical year is not quite constant, moreover, that question may be left to astronomers. The other objections are that the commencement of the year does not coincide with any season, that the length of the month is more irregular than necessary, and that the names of some months do not concord with their number (October is the tenth month). Bigourdan (*Comptes Rendus*, January 6, 1919) considers that these difficulties might be settled by convention. It might be, if the Académie des Sciences, which he addressed, were the only body to be consulted. But the seasons vary with the hemisphere and situation of a country, and as regards the first point mentioned, the disagreement between dates and week-days, little would be gained by adopting Bigourdan's suggestions. He would either make the year consist of 364 days plus one or two extra days, not to be fitted into the ordinary week; thus he would place one (or in leap years two) blank day between Saturday, December 31, and Sunday, January 1. As this interference with the week, the unique element of the calendar, which is the same all over the earth, would probably be objected to, he would, according to his second suggestion, divide the year into four trimesters, the first three of these to consist of one month of 31 days, followed by two months each of 30 days. These three trimesters would thus be of $31 + 30 + 30 = 91$ days $= 13$ weeks exactly, and if the first month began with a Monday, the second month would start with Thursday, and the third with Saturday, the same in all the three trimesters. But the fourth trimester would consist of two months of 31 days and a third of 30 (or 31 days). There would thus be less irregularity than at present, but that small advantage is certainly not such as to warrant our running the serious risk of upsetting our calendar.

DROP-FORGING PLANT AT VICKERS' RIVER DON WORKS, SHEFFIELD.

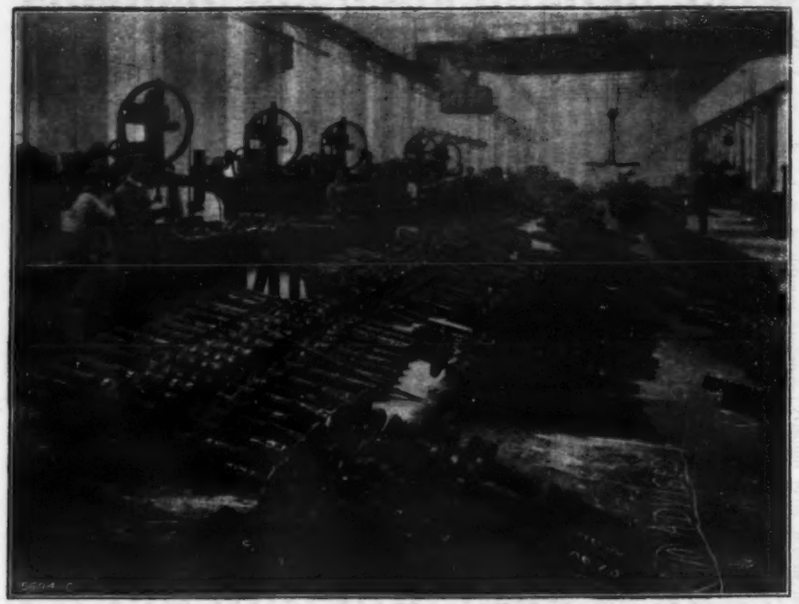


FIG. 1. DROP FORGED CRANKSHAFT LAID FOR TESTING.

FIG. 2. GALLERY WHERE TEST-PIECES ARE PREPARED.

AN interesting development in the drop-forging art, and at the same time a valuable addition to the country's resources, may be found in the new extension to the drop-forging department of Messrs. Vickers, Limited, at their works at Sheffield.

Owing to the fact that technical literature published in this country finds its way into enemy hands, it is not thought advisable to give minute details of a plant of this nature, but it is hoped that the reader will be able to form a very fair impression of this up-to-date plant from the following brief description, and the engravings published on this page and on page 178. These several views give a general conception of the comprehensive character of this self-contained department. Fig. 1 above shows the crankshafts laid out for testing; but it must not be assumed that only crankshafts are produced, there being little limit to the forgings in respect of form or purpose up to considerable weight. Fig. 2 is a view of the gallery where test pieces are prepared, while Fig. 3 is a view of the testing laboratory—the existence of which is a further indication of the completeness of the department. Fig. 4 on page 178 shows the heat treatment furnaces and the oil and water quenching tanks. The last view of the series—Fig. 5, on page 178, gives a good idea of the extent of the department and its equipment.

The plant, which was designed primarily to meet the enormous and exacting demands of the Air Ministry and other Government Departments for six-throw crankshafts, is housed in a structural steel building of one central span 55 ft. wide with a 22 ft. "lean-to" on either side, the total length being 525 ft. Fig. 5, on page 178, shows this main shop.

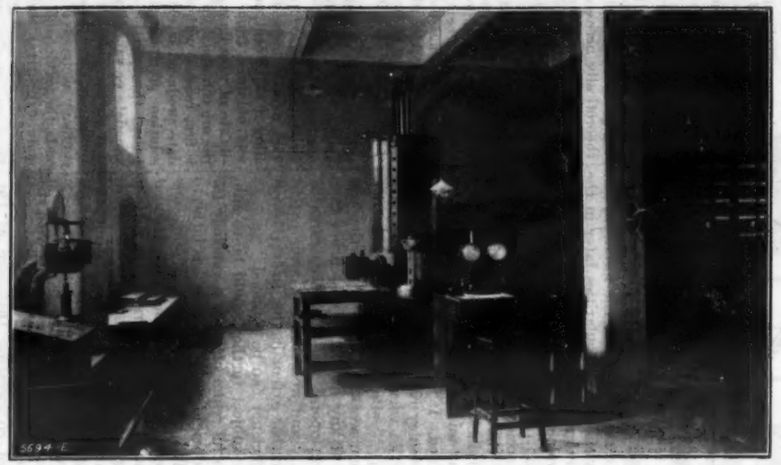


FIG. 3. TESTING LABORATORY.

Particular attention has been paid to ventilation with the object of reducing to a minimum the bad effects of the smoke. The lay-out of the plant is arranged so as to give what might be termed a constant flow of material, which, as it passes each stage of manufacture moves only in one direction. The drop hammers of the Massey steam-lift type range in weight from 50 cwt. to 90 cwt., and are erected down one side of the central span, the necessary steam being derived from a number of Cochran boilers connected in series and each driven from the waste heat of two coal-fired furnaces. Thus it will be seen that each drop hammer unit comprises besides the hammer itself, two coal-fired furnaces and one waste heat boiler. On the opposite side of the central span steam hammers of the Rigby type are arranged so that their product of "uses" travels a minimum distance before reaching the drop hammers. The Rigby hammers are also driven by steam generated in waste heat boilers. Furnaces and boilers on both sides of the shop are housed under the "lean-to" spans, thus keeping the central span free from smoke and unnecessary dirt. For bending the bars intended for crankshafts to the rough shape, specially designed presses varying in capacity from 250 tons to 350 tons are used, and have been placed on the same side of the central span as the steam hammers. Each hammer is fitted with two jib cranes of Messrs. Vickers design which is based on years of practical experience.

The transport of material inside the shop is amply provided for by electric travelling jib cranes of 5 tons capacity each, whilst the exterior transport is taken care of by a Telpher runway.

The processes in the crankshaft manufacture, such as twisting heading, heat treating and straightening, are carried out as far away from the hammers as possible. This is most desirable in the case of heat treatment, as the furnace temperature recording instruments are of such a delicate nature that constant vibration affects their accuracy. A view of the heat treatment furnaces and the oil and water quenching tanks is shown in Fig. 4, on page 178.

The battery of heat treatment furnaces is supplied

with coal gas from two Wincott producers, the arrangement giving very satisfactory results, whilst a pyrometric installation supplied by the Cambridge Scientific Instrument Company and ample cooling arrangements for the oil quenching tanks complete an up-to-date heat treatment plant.

Facilities are provided in an adjoining building 460 ft. by 52 ft. for cutting off test pieces, preparing and testing. One end of this building is also used for maintenance purposes. Fig. 1, on page 168, which, as already stated, shows the crankshafts laid out for testing in this shop, will give the reader an excellent idea of the enormous quantity of shafts it is necessary to have in a state of flux in order to maintain the output.

In the same way Fig. 2 indicates the extent of the large amount of work to be done in the preparation of the test pieces required. The test house, which is situated immediately below the gallery, occupies approximately 60 ft. of the building.

Ample accommodation is provided in the test house for the inspecting staff as well as the testing staff, and every credit is due to Messrs. Vickers, Limited, for the practical way in which they have faced the problem of designing and erecting, under war condition, the factory above described, which is capable of producing approximately 1,000 crankshafts per week.

OXY-ACETYLENE WELDING.*

By J. H. DAVIES, of the Central Technical School, Leeds.

IT is well-known to every one who takes an interest in autogenous melting and welding processes, that the existing opinion as to the value of the processes, and the practical results obtained differ widely. The chief ground for the uncertainty that exists in regard to them lies in the fact that these new processes have only recently been introduced in industrial practice, and rest entirely upon empirical bases. Although oxy-acetylene welding is now extensively practised and is of great theoretical and practical interest, it has never been made the object of systematic and exhaustive research.

The author has had eighteen years' experience in the welding process and has made exhaustive tests, and long studies, not only of what is being done in this country, but also of the progress made, both in the United States and Germany, the latter country being far more advanced than Great Britain in the oxy-acetylene process. They have carried out systematic and exhaustive researches, their operators are scientifically trained, they are taught metallurgy and chemistry, including the chemical compositions and melting-points of all metals and oxides, they make test-pieces for experimenting with chemical and mechanical tests, and by microscopic and macroscopic examinations, both of the melted zone and the neighbouring parts, their welding as a rule is very neat, as they are not allowed to execute commercial work until they have become fully proficient and competent.

The author has undertaken many investigations in the oxy-acetylene processes on autogenous welding of various metals in general use; in doing so he has endeavoured to adhere as closely as possible to conditions which accompany ordinary works' practice. The oxy-acetylene processes when properly worked possess numerous marked advantages over all others. In the first place, the operating flame can be easily controlled, and the temperature attained at various zones can be readily regulated.

In the second place, the work can be readily accomplished owing to the high temperatures reached (3,500 deg. C.). The appliances are easy to handle and reliable in operation.

The most important conditions for securing good results are :—

1. The use of the purest acetylene possible.
2. The use of a blowpipe so designed as to ensure accurate adjustment in the proportion of the mixed gases, and to secure their exit at a velocity capable of maintaining the metal sufficiently fluid without the melting flame being too rigid.
3. The use of an absolutely pure welding rod.
4. The provision of an absolute neutral zone in the melting flame, neither oxidising nor reducing.
5. The edges must be free from all impurities, and if over $\frac{1}{16}$ in. thick the edges must be bevelled, if over $\frac{1}{4}$ in. the edges must be bevelled on both sides.
6. The use of deoxidising agents eliminating the oxides in view of unavoidable oxidation of the metal subject to the melting process. It is necessary to bear in mind the relation between the melting-points of the oxides and that of the metal itself, which is a most important matter.
7. Rapidity in melting in order to avoid excessive heating, which will not only alter and deteriorate the original structure of the metal, but would even favour the occlusion of gas (particularly hydrogen), and so occasion the formation of blowholes in the melted zone.

In addition to these considerations, care should be taken to see that no sudden cooling takes place. The conditions may have to be modified on account of the conductivity and specific dilation of the material, as well as to the relation to the thickness, size, and shape of the pieces operated upon.

These precautions were observed in the author's experiments, and particular attention was given to the changes in chemical composition and mechanical properties, by careful examination of the melted zone, and the structure of the welded material was compared with that of the original. Experiments were, moreover, carried out on molten metals both before and after subjection to mechanical stresses, in order to ascertain to what extent, if any, the various constituents are influenced by the process. The researches were further carried out on the mechanical properties of various steels when subjected to the strong heat of the flame, without being melted, and for the same period of time as might be required for the autogenous welding of the same sized pieces.

The first experiments were carried out on boiler plate 0·393 in. thick, of which the chemical composition was as follows :—

	Per Cent.
Carbon	0·105
Manganese	0·510
Silicon	0·024
Phosphorus	0·025
Sulphur	0·053

0·473 in. diameter bars, whose chemical composition was as follows :—

	Per Cent.
Carbon	0·700
Manganese	0·930
Silicon	0·190
Phosphorus	0·049
Sulphur	0·057

Welding rods were used containing 0·600 per cent. carbon, and during the welding a deoxidising and descorifying powder was used, consisting essentially of sodium carbonate, Table III, subjoined.

Summarising these observations on carbon steel shows that :—

1. The violent heating and the sudden melting undergone by the metal profoundly alter its quality.
2. The alteration in the mechanical qualities (tenacity and elasticity) cannot be remedied by simple hammering on the melted zone (which often proves to be most injurious to high-carbon steels), but must be coupled

TABLE I.

Sample.	Orig. Thick.	Mach. Thick.	Thermal Treatment.	Break Stress.	Elongation on 2 In.	Metal.	Welded Zone.	Cold Bend.	Notes.
				tons per sq. in.	per cent.	per cent.	per cent.		
1	0·393	0·236	Heated and cooled in air	23·0	16·0	—	—	—	Subject to high temperature of flame. Not welded.
2	0·393	0·236	Heated and tempered to 900 deg. C. for 20 minutes	23·0	19·7	—	—	—	,, ,,
3	0·393	Not mach.	Welded only ..	19·0	5·8	C 0·125 Mn 0·40 Si 0·047	C 0·07 Mn 0·32 Si —	—	Broke through weld Grain coarse.
4	0·393	0·236	,, ..	—	—	—	—	180 deg. without trace of flow	—
5	0·393	Not mach.	Not hammered, weld slowly cooled	23·0	13·5	—	—	—	Broke at weld, fine. Slightly fibrous structure.
6	0·393	0·236	,, ,,	22·8	14·0	—	—	180 deg. without trace of flow	—
7	0·393	0·236	Welded and air-cooled	—	—	—	—	160 deg. flow at weld	—
8	0·393	0·236	Tempered, 20 minutes to 980 deg. C.	23·4	10·5	—	—	—	Broke at weld. Grain coarse.

TABLE II.

1	0·786	0·472	Tempered to 900 C. for 20 minutes	28·7	30·0	—	—	—	Not welded.
2	0·786	0·472	Heated to incipient smelting of furnace	27·4	28·5	—	—	—	,,
3	0·786	0·472	Slowly cooled ..	26·2	1·3	C 0·125 Mn 0·40 Si 0·0	C 0·08 Mn 0·29 Si —	—	Broke at weld. Rough granular structure.
4	0·786	0·472	Heated and hammered slowly. Cooled in air	24·6	10·0	—	—	—	Broke at weld. Inner, fine. Outer, coarse grains.
5	0·786	0·472	Annealed 900 deg. deg. for 40 min. Cooled slowly	27·0	29·0	—	—	—	Broke outside weld.
6	0·786	0·472	Hammered hot. Annealed 900 deg. C. for 40 minutes	27·4	26·3	—	—	—	,, ,,
7	0·786	0·472	Preheated and hammered twice. Two consecutive anneals. Slow cooled	27·4	29·2	—	—	—	,, ,,

TABLE III.

1	1·022	0·473	Heated and cooled	54·3	13·6	—	—	—	Subjected to high temperature of flame. Not welded.
2	1·022	0·473	Heated and tempered to 900 deg. C. for 20 minutes	55·9	16·1	—	—	—	Not welded.
3	1·022	0·473	Slowly cooled after welding	37·8	2·1	—	—	—	Broke at weld. Rough grain structure.
4	1·022	0·473	Heated and hammered after welding. Cooled in air	36·2	0·0	C 0·60 Mn 0·91 Si 0·20	C 0·32 Mn — Si 0·10	—	,, ,,

The welding rod used was pure Swedish charcoal iron, $\frac{1}{4}$ in. diameter, practically free from sulphur and phosphorus.

After the samples were welded, some were cooled in air, others went under special heat treatment and mechanical operations, finally mechanical tests were made on rough unmachined samples; before and after mechanical tests a piece of metal was taken from the melted zone and from the neighbourhood of the weld for microscopic examinations, Table I, above.

A second series of the same nature were carried out on round bars of mild steel. The chemical compositions were :—

	Per Cent.
Carbon	0·119
Manganese	0·620
Silicon	0·023
Phosphorus	0·066
Sulphur	0·062

The welding rod was of Swedish charcoal iron wire, $\frac{1}{4}$ in. diameter. The experiments were carried out as for the first series, except for the mechanical tests, the pieces were machined to 0·472 in. diameter, this being done to compare the quality of several welds. The results are given in Table II, above.

A third series of experiments were made on medium-carbon steel, using 1·022 in. diameter, machined to by proper thermal treatment, such as annealing carried on for 30 minutes or 40 minutes; further quenching has also the greatest influence on high-carbon steels.

3. A remarkable influence on the mechanical properties is to be attributed to cooling processes, the slowest cooling being the best and most efficient.

4. Apart from the alteration in mechanical properties, very important modifications take place in the chemical constitution; these changes consist chiefly in diminution in the percentage of carbon, silicon and manganese, but the author thinks that this defect may be modified by using a welding rod with a higher percentage of these oxidisable elements.

For those familiar with the oxy-acetylene welding and cutting process, it is not difficult to appreciate its varied applications and important advantages, especially in time of war, and the author feels quite justified in saying that the present war has given a stimulus to oxy-acetylene welding, which ten years' ordinary industrial progress would never have done.

The ease and rapidity with which experienced welders can carry out repairs *in situ*, and the portability of the plants, make the process valuable, if not indispensable, at the Front. The service rendered by this process in the many workshops attached to the armies is particularly valuable, where the welding of articles of all kinds is a daily necessity.

The oxy-acetylene process occupies a leading place in

* Paper read before the Institution of Mechanical Engineers, on Friday, January 24, 1919.

the aeroplane and airship industries; it has the advantage over all other systems of joining, in diminishing the weight of parts, so that parts previously made from wood or aluminium castings are now made both lighter and stronger from sheet and steel tube. The frequent repairs to engines, and other details, including the repair of cracked cylinders and broken aluminium crank and gear cases, further emphasise the new power the process offers to the aircraft industry. Further, the value of cutting with this process has no rival whatever, and the ravages of warfare open up an extensive field for it, both during and after the determination of the war. The demolition of bridges and steel structures blown up by the Allies or enemies is an important application of this process. The cutting of armour plates again emphasises its unique field of usefulness.

The oxy-acetylene flame has recently been applied to the case-hardening process, and some firms are using this on a large scale. It is well known that the flame containing an excess of acetylene is a very energetic carboniser. If the flame is held for a period of 2 minutes on the white hot surface, a hardness equal to that obtained with the most energetic case-hardening mixture is obtained; if this is prolonged from 5 minutes to 10 minutes, it will penetrate to ¾ in. depth.

The many advantages oxy-acetylene has over other processes may be summarised as follows:—

It can be applied to almost any class of work; it can weld 30 gauge steel or 1½ in. thick boiler plate; it can cut mild steel up to 24 in. thick; and it will weld any commercial metal such as cast-iron, aluminium, copper, bronze, lead, zinc, &c.

In the repair of broken machinery and parts, it has no rival, the repairs can be executed quickly, and many repairs may be executed without dismantling, the cost in many cases is infinitesimal, compared to the cost of a new part.

It can now be used with advantage, in the manufacture of safes, tanks for oil, caustic soda or other solutions, the jointing of pipes, steam superheaters, metal casks, petroleum barrels, artistic ironwork, adding metals to parts worn by friction, filling up holes or parts of new structures cut away in error, welding of tool-steel ends to common steel bars for turning and cutting tools, the welding of copper, brass or iron tubes.

The equipment is extremely portable, and can be used within a few minutes of being loaded, the power of the heating flame can be far more accurately regulated than electric current. The flame can be used for preheating, hammering, and annealing after welding, thereby insuring a uniform soft metal, a method not practicable in the electric process.

In the welding of light sheet steels, it has an unrivalled field; with 24-gauge metal, 45 ft. per hour can be welded, with a consumption of only 4 cub. ft. of oxygen and 3 cub. ft. of acetylene. On the other hand, when the metal reaches ¾ in. thick or over, electric welding has the advantage both in speed and cost.

When the process of oxy-acetylene welding was first introduced into this country, its apparent simplicity led many engineers wrongly to assume that welding appliances might be regarded as general workshop tools, which any inexperienced but handy man could operate with success; consequently much work has been condemned wholesale because of defects in the weld, but the author would emphasise that this is not the fault of the process, but of inefficient workmen. To-day the business has grown beyond the limit of personal supervision, and the necessity for organised instruction of operators is becoming more and more obvious, both in the interests of workmen and employers.

Welding schools are now established in various centres and a stream of fairly qualified welders is already flowing from these schools into workshops. They teach the students under practical conditions of the kind of flame for different work, the principles under which the blowpipes are constructed, the way to handle them, and a variety of practical and technical points which are bound to be most helpful to them in their subsequent career. No man should be regarded as a competent operator until he has a clear and intelligent understanding of all points appertaining to the process; he should be a fair metallurgist and chemist, and know the melting-points of all metals and oxides and chemical compositions, and be conversant with mechanical and thermal tests.

There are estimated to-day to be not less than 30,000 employees in this country working the process of oxy-acetylene welding; 20,000 of these entered the field since the war began. Of the total number 90 per cent. are not fully skilled, that is, they are incapable of executing satisfactory welds on all metals, being mostly employed on sheet steel work for war purposes. The impetus that has been given under war conditions should stimulate employers at the conclusion of hostilities to investigate and exploit this revolutionary process, whose vast possibilities have no obvious limits.

In the shipbuilding trade this process can be utilised a hundredfold more than at present; for instance, in making of knee brackets, stays and frames, these can be all cut and welded by blowpipes, with present costs reduced, and output increased; a blowpipe only requires one man, but an angle-smith when welding a knee bracket requires two or three assistants. The author only mentioned this one item, but there are dozens of others; most shipyards have plants, but they are not often utilised to advantage, for they must either employ skilled welders or call in an expert to advise.

This process is not being neglected in some works, and those who have grasped its possibilities consider it a unique labour-saving tool. The author personally knows of a locomotive shop, where 20 welders are employed, and 6,000 ft. of piping have been installed for carrying gases to all the shops. They have more than 400 locomotives in use with welded fire-boxes and 500 welded engine frames, and they have reclaimed in one month 157,082 bolts, thus saving 400*l.* compared with new ones. Repairs to shop tools, machinery, &c., are common, and excellent results obtained, the housing for a large roll was repaired by this process, welded in a day and a half; a new housing could be obtained under six weeks. A planer broke whilst operating on a cylinder of an engine; a new part could not be got under 10 days, but with the blowpipe, the part was welded, and the planer at work in 2 hours 45 minutes. These examples might be multiplied considerably.

THE DEVELOPMENT OF THE OXY-ACETYLENE WELDING AND CUTTING INDUSTRY IN THE UNITED STATES.*

By Henry Cave, of Hartford, Conn.

Though the United States has the honour of having started the commercial use of acetylene through the discovery of Thomas Willson, at Spey, South Carolina of the method of making calcium carbide with the electric furnace and the possibilities of generating acetylene therefrom, and has made rapid strides in its use for lighting purposes, this country was backward at the inception of the use of acetylene in conjunction with oxygen for welding and cutting. In Europe, the use of hydrogen in this latter respect was a forerunner of the use of acetylene, but its use for these purposes did not reach America until even later than acetylene, except for the fusion of rare metals.

The earliest record of the oxy-acetylene torch in the United States was the receipt of one in 1903 by Eugene Bournonville, a Belgian engineer, residing in the United States, from his friend Edmond Fouché. This torch was used to a slight extent, operating with medicinal oxygen as no other supply was available at that time. The first commercial development was probably the formation in 1905 of the Industrial Oxygen Company to exploit the Joubert equipment of the Société L'Oxilite Company. André Beltzer, a French chemist, went to the States to introduce the process, and a demonstration plant was established at the Fore River Shipbuilding Company, Quincy, Mass. The torch sold by this company was of the injector type, having changeable outer and inner tips so as to vary the flame. A submerging-tray type of acetylene generator was used, and oxygen was produced by the so-called "Epurite" process which employed, using warm water, the combination of a calcium compound with copper sulphate and sulphate of iron. The extensive introduction of this equipment was prevented by the high price charged, which was about 2,000 dols. for equipment.

An Englishman, Cecil Lightfoot, in the meanwhile established at Buffalo, New York, a plant for the production of oxygen from liquid air by the "Linde" process, and, at the same time, purchased the Fouché patents and introduced that torch into the States. Use was made of low-pressure lighting generators as a source of supply of acetylene, as such generators had been produced in the States, for years, and had been developed to a high state of efficiency.

Augustine Davis, who had been, from the inception, a fertile inventor in the field of acetylene lighting equipment, as well as an extensive manufacturer of this apparatus, visited Europe in 1906, as a delegate to the Acetylene Congress from the International Acetylene Association of America. Learning of a new use to which acetylene was being put, he investigated the matter and became interested. He learned that Eugene Bournonville was in Paris, similarly interested, and, upon meeting him, he arranged for a conference in New York, resulting in the formation of a company to exploit the oxy-acetylene process.

Davis and Bournonville visited Europe again and made a careful study of the status of the industry and of the various equipments in use, and made arrangements with Rodriques et Cie, to exploit the patents of their medium-pressure (French rating) torch in the United States, having determined that this torch was the most promising of the various developments that had taken place abroad. When Mr. Davis returned from France he brought an expert French workman with him, one skilled in the art of welding and cutting. The cutting equipment at that time merely consisted of a piece of tube with a screw needle valve clamped to the side of the welding torch. This required a separate hose, regulator and tank of oxygen, and was very inefficient as compared with the wonderful results that are being obtain at this time.

In Europe the use of dissolved acetylene had advanced further than in the United States, probably due to the higher development of the automobile industry there at that time, and the fact that the shorter distances made the general distribution of tanks a much easier problem than in that vast country. Mr. Davis, learning that he would be handicapped in the development of the process by being dependent upon dissolved acetylene, proceeded to design a pressure generator, which would provide gas compressed as required by the medium-pressure type of torch, but not exceeding 15 lb. per square inch. This pressure had been found to be safe—acetylene never having been known to dissociate at pressures less than about 25 lb. under any conditions. The development of the industry in the States was greatly assisted by the purity of the carbide produced by a large concern at Niagara Falls, making it unnecessary to use any purifying means, either from the point of view of safety or the effect the purity might have on the welds.

Oxygen was, at that time, a considerable cause for anxiety to most of those engaged in the infant industry, as the only really reliable source of supply was that of a company selling a competitive equipment and, therefore, not likely to give the best service to other than users of their own equipment, which service was very precarious, owing to the scarcity of cylinders in which the oxygen had to be shipped long distances from the one charging plant in this country. The price of oxygen was high, making the process prohibitive for a large amount of work which otherwise could have been very successfully carried out.

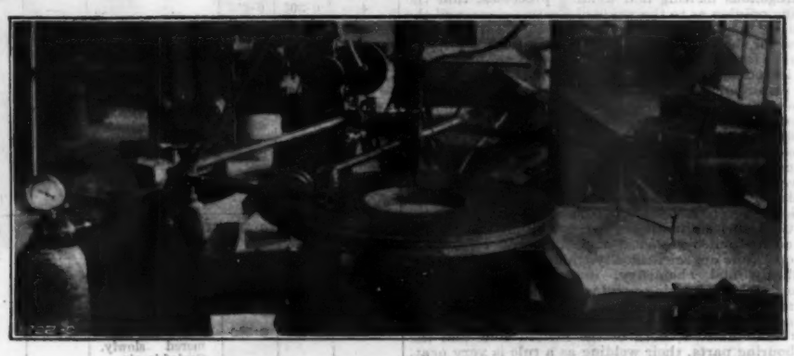


Fig. 1. The Oxygraph.

About this time Bournonville developed a satisfactory small plant, enabling individual users to produce oxygen from chlorate of potash, and supplied a compressor with the equipment to store the gas, first at 250 lb. per square inch, and later at 300 lb. Manganese dioxide was used as a catalyser so as to generate the gas at a low temperature. Other equipment manufacturers developed similar plants in which the heat was produced by internal combustion, carbon being mixed with the potash. These developments relieved the situation to a considerable extent. Oxygen-supply companies now started up spasmodically, but were shortlived. This was mainly due to the shortage of cylinders and their high cost, not being produced in the country, cylinders had to be imported from Europe.

Financial interests connected with a large calcium carbide company took over the Buffalo oxygen plant, separating the apparatus business from the sale of oxygen and adopting a broad policy of supplying all users on an equitable basis. They immediately started to build additional plants in various parts of the country, established warehouses, and purchased cylinders in large numbers. This gave a tremendous impetus to the development of the industry, both advantageously and otherwise, for not only did it help the concerns that were striving to develop the business on a sound basis, but it brought into the field a large amount of cheap apparatus that was sold to users without any instruction. A great deal of this apparatus came into the possession of irresponsible parties, who charged exorbitant prices for extremely unsatisfactory work. This gave the process a bad name and retarded its development to such an extent that even to-day its effects are felt in the States.

The dissolved acetylene business was also labouring under a handicap. The owners of the patents had developed a business in connection with railroads and other commercial interests, and had licensed another concern to supply gas for the automobile industry in tanks of limited size. These tanks were not suited to welding purposes, and prices were prohibitive. The parent company refused to supply dissolved acetylene for welding and cutting except where the cylinders were purchased outright; and, as the charge for a cylinder of 225 cub. ft. capacity was at that time 150 dols., very few of them were sold. Such short-sightedness eventually had its own reward by producing competition even in the

* Paper read before the Institution of Mechanical Engineers, on Friday, January 24, 1919.

face of the patents, the competitors being more generous in supplying the gas without the owning of the cylinders, thus adding an additional impetus to the development of the industry and also unfortunately to the scattering broadcast of cheap welding outfits.

As has been noted, up to 1909 the use of hydrogen had not developed in the States except for a few special uses, as the expensive method of generating the hydrogen by the zinc and acid method was used. In this year, however, the American Oxy-Hydric Company installed electrolytic cells in Milwaukee, Wisconsin, and started to introduce the oxy-hydric process, taking over the Jottrand patents of the Belgian Company, of a somewhat similar name, which had made remarkable development. This company was not a financial success, however, for a number of causes, the chief of which was probably the fact that cutting of steel had not been developed to any extent in the States at that time, and, as is well known, welding by means of hydrogen does not compare favourably with the use of acetylene, except on extremely thin metal, for which there was very little scope in this country. The high price of labour made prohibitive all hand work in connection with the manufacture of the numerous small articles which were being welded abroad by this process. The company was then taken over by the same interests that absorbed the other oxygen company. More recently, however, other large companies have come into the field and established oxygen plants of both the electrolytic and liquid-air process in different parts of the country.

During the last five years the electrolytic process of manufacturing oxygen has been given a great deal of attention, with the result that several concerns have manufactured and sold a considerable number of plants, which have proved very reliable when operated properly, both as to the purity of the gas produced and the safety of the process. These equipments have been very largely used for production of hydrogen for the hydrogenation or hardening, of oils, as there is a considerable scope for the process among the big packers of the States. Of course, oxygen in large quantities is produced as a by-product.

For several years the processes of both welding and cutting were carried out entirely by hand. The American Oxy-Hydric Company, however, introduced some machine-cutting devices, such as were used by their parent company in France and Germany. These equipments, however, were mainly hand-driven, and, therefore, were not a great improvement over the free-hand method, neither did they meet with a ready sale.

About 1909 Thomas A. Edison introduced from abroad some special machines to weld automatically the seams of the containers used in his storage batteries, these probably being the first machines to be used in this country for actual commercial work. The development of machines of this nature seems to have been neglected entirely in the United States except by the Davis-Bournonville Company and a few concerns who have made devices for special purposes for their own use.

The Davis-Bournonville Company has expended large sums of money in developing machines of a variety of types for both welding and cutting; in a general way using an electric motor for their operation, but in a few cases being driven by hand-operated mechanisms. The illustrations show several types of these machines. Fig. 1, page 170, represents what is probably the most remarkable development of metal working of the century, the "Oxygraph." This is a cutting machine made on the pantograph principle, being arranged so that the cutting torch can be guided accurately and travel at a uniform speed, so as to cut a shape out of steel, as

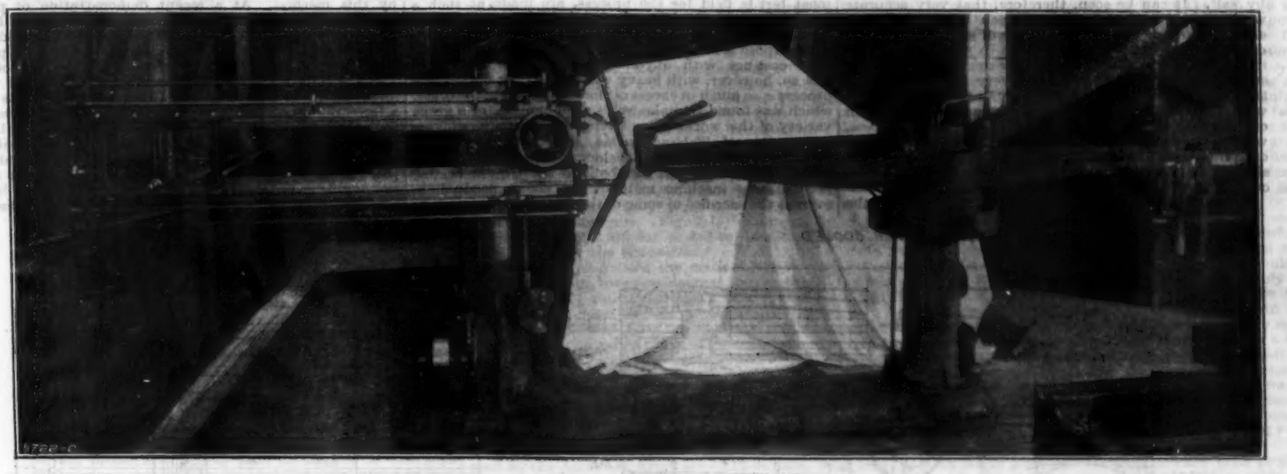


FIG. 2.

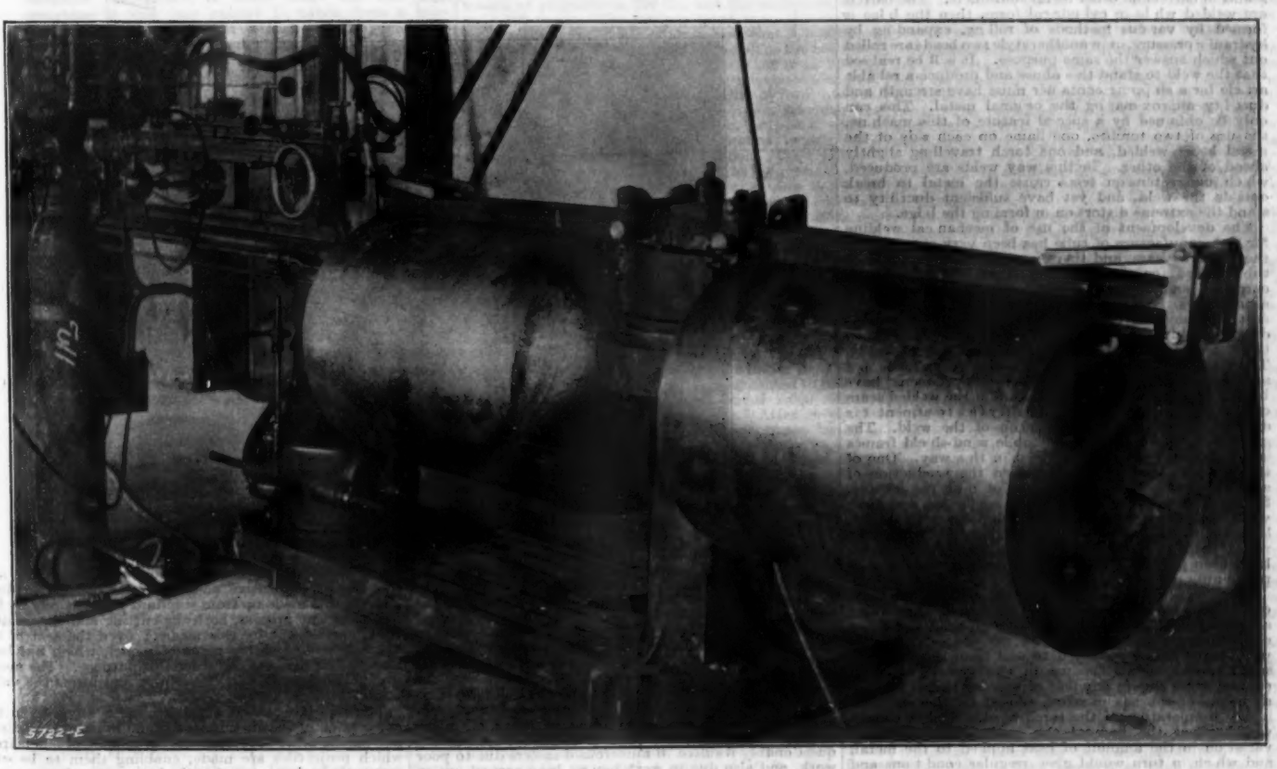


FIG. 2A.

FIGS. 2 AND 2A. THE DUOGRAPH; FLAME ON BOTH SIDES OF WELD.

represented on a drawing, which is carefully followed by means of a tractor-wheel, steered along the lines of the drawing, as a bicycle around a track; the tractor wheel is driven by a small electric motor, controlled by a governor, which gives an absolutely uniform traverse of the torch, and at the same time variable speeds at the will of the operator. It is a comparatively easy matter, on the majority of shapes that would be required to be cut, to steer the tractor wheel around the lines with an accuracy of $\frac{1}{16}$ of an inch, and as, in one type of this machine, the cutting is carried out with a reduction of two to one from the traverse wheel, any error is reduced by half. It can be seen, therefore, that very accurate work can be produced. Designs can be cut with this accuracy and with any irregularity of shape at the rate of from 6 in. to 10 in. per minute in steel up to 2 in. in thickness, and at a lesser rate for thicker metal. The smoothness of the cut compares very favourably with the regular machine-shop roughing machine tools. It will be seen that a tremendous saving can be made in cutting dies and many other regular or irregular pieces, which by the ordinary machine-shop method prove extremely tedious to produce, and take up the time of skilled workmen who could be far better applied on other work.

Fig. 2, page 171, illustrates a machine called the "Duograph," designed for the welding of the longitudinal seams in barrel and other metal containers. The barrels are welded while in cylindrical form, then the bilge is formed by various methods of rolling, expanding by hydraulic pressure, or in another style two beads are rolled out which answer the same purpose. It will be realised that the weld to stand this abuse and produce a reliable article for a shipping container must have strength and ductility approximating the original metal. This can only be obtained by a special feature of this machine, the use of two torches, one flame on each side of the metal being welded, and one torch travelling slightly ahead of the other. In this way welds are produced, which under tension tests cause the metal to break outside the weld, and yet have sufficient ductility to stand the extreme distortion in forming the bilge.

The development of the use of mechanical welding for the manufacture of tube has been very extensive in the last few years, and there is a very large amount of tubing used for the construction of bedsteads, baby carriages, and in various parts of the cheaper grade of automobiles being manufactured in this way. The cost, of course, is very much lower than for the solid-drawn product, and when the welded tube is re-drawn there is very little difference in appearance or accuracy. The abuse that a welded tube will stand when made in a satisfactory manner is remarkable. Specimens have been squeezed up under a press without the welded seam opening up in any way, and even after the treatment it is difficult to determine the location of the weld. The grooved tubing used for automobile wind-shield frames is very extensively manufactured in this way. One of the developments which has helped the production of articles of this nature is the use of multiple jet-tips. Such tips are made with as many as six flames, and these weld very much more rapidly than with a single jet, less heat being dissipated sideways into the body of the metal than with the equivalent single flame. Welds have been produced with these tips at the rate of 8 ft. per minute, without preheating.

However, it has been found necessary, on this class of work, to use a water-cooled torch, Fig. 3. The water circulates completely through the torch head and down close to the point of tip, Fig. 4, on one side, passing up the other, and conveyed to and from the torch by small rubber hose. The use of this system of water cooling is not due to any fear of burning the tip, but to a change of the gas mixture, caused by the variation in the temperature of the torch head. Such a change would affect the flow of the gases, thus producing variation in the amount of heat applied to the metal, and which in turn would give irregular conditions and require constant watching by a skilled welder, who would from time to time have to change the gas mixture or vary the rate of speed of the material passing under the flame to compensate for such variations. Even with the best possible operator, the results would not be in any way comparable with that produced by a water-cooled torch with a comparatively unskilled machine tender. The size of the flame and the speed of traverse would, of course, be determined by an expert and standardised for the various thicknesses and conditions of material.

The use of the welding torch operated by hand has attained tremendous proportions in connection with repair work, particularly on broken parts of automobiles, and in connection with the repair of breakages of the higher grades of cars, spare parts for which are comparatively expensive. For a time the welding of automobile cylinders, cracked due to freezing in winter, was very extensively carried out. In the last two or three years, however, the knowledge of the requirements of an automobile in this direction has spread so generally as largely to eliminate trouble from this cause.

The welding of defective castings in the foundries has not developed to an extent that might be expected, mainly due to the difficulties encountered in connection with the expansion and contraction, and the hard metal resulting from the inferior welders that were frequently employed. To a very large extent the fact that foundries sell their castings, and their customers object to receive material that has been fixed over, mitigates against this use, and that small castings, which would produce the most fertile field for the process, are made at such a low labour cost (the labour being the only saving, as the iron can be used over again), the use of the process for this purpose is largely eliminated. The welding of small steel castings with oxy-acetylene is quite extensive. Not so, however, with heavy castings, as the cost of the process is so much in excess of that of the electric process, which was found to make welds good enough for a great variety of this work, where strength is not required.

The Use of Welding in the Manufacture of Small Articles.—This has not developed to a large extent, owing to the high cost of labour in the United States, necessitating machine methods for cheap production, even at the sacrifice of some of the advantages of designs that might result from the use of hand methods such as oxy-acetylene welding.

Welding on Steam Boilers.—This is practically limited to repair work, of which there is a considerable amount in marine boilers, but a comparatively small amount in land boilers, except ng possibly locomotives. Restrictions of some of the State authorities and by all of the insurance companies had advisedly kept down the amount of this work, and to some extent also the welding of pressure containers; otherwise, the large number of cheap equipments in the hands of unskilled operators employed by irresponsible concerns would have unquestionably resulted in numerous disasters due to poor work, and also due to work having been carried out in locations that would make it inadvisable. Certain operations, such as the welding of the fire-end of boiler tubes to the tube plate, are being carried out almost entirely by the electric method, as the large amount of heat put into the plate by the slower oxy-acetylene process causes trouble.

Welding of Malleable Cast-Iron.—This is entirely carried out by the use of Tobin bronze rods, all other materials having proved unsatisfactory. The difference in colour of this adding metal and the generally small value in malleable iron castings make it prohibitive for the repair of defective castings in the foundry.

Welding of Monel.—Considerable study has been given to this natural alloy of copper and nickel, which presents unusual difficulties to satisfactory welding. One firm is now turning out monel tubes formed up from sheet and then welded by this process.

Welding of Gas Mains.—This has developed very rapidly within the last two or three years for high-pressure service between townships. The welding of the large mains for the Panama Pacific Exposition, and the subsequent publicity, gave a great impetus to the use of the process for this purpose. At the present time, however, there is not much of this work being done, owing to the high price of pipe, and to the increase in price of metals resulting from the demands of the European war, making it undesirable at this time to carry out numerous extensions in gas mains, which otherwise would have been installed. Some remarkable results are being obtained in the speed of laying pipes by this method. At a recent demonstration of pipe welding before a Convention of Gas Engineers, 4 in. I.D. pipe was welded in 3 minutes 20 seconds actual welding time, and at another demonstration, joints in 2-in. pipe were made at the average rate of 1¼ minutes per joint. These results show the best possible practice, but unfortunately very much slower times are being made by a large number of welders, due partly to the failure of the concerns to realise the necessity of using skilled operators, and partly due to the scarcity of really skilled operators, and the large wages that they command in this country. Flanged or threaded connections are not reasonable at the valves in an otherwise welded pipe line. The cast-iron valve casings usually used are very liable to break and cause trouble, and even loss of life, and cast steel is expensive and unsatisfactory for welding. The valve is made up from standard pipe entirely by the oxy-acetylene process, both the cutting and the welding being carried out by this means; even the seat of the valve is welded, being made of monel, which has been found to be the best metal for this purpose. The monel is deposited on the end of the pipe and forms the valve seat.

Fig. 3. WELDING TORCH, WATER COOLED.

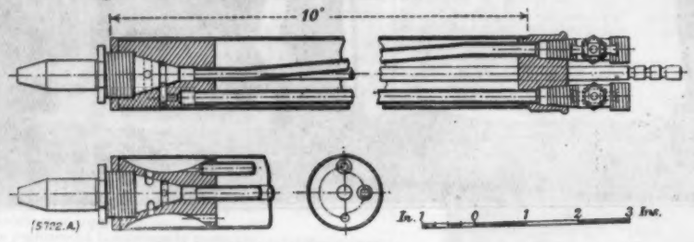


Fig. 4. MULTIPLE WELDING TIP, WATER COOLED.

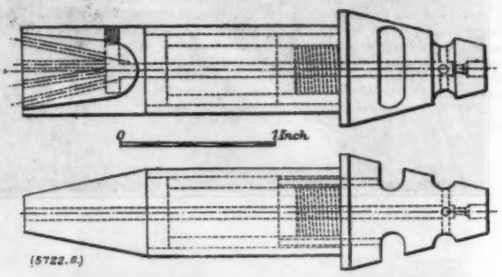


Fig. 5. The Radiagraph.

The war has caused a much greater advance in the application of the cutting torch than in that of welding; and among other developments the nicking of billets from which projectiles are made, enabling them to be subsequently broken up so that the fracture can be examined is being carried out very extensively at the present time.

The Cutting of Risers in the steel foundry has become very general, some foundries having almost eliminated the use of mechanical methods of cutting.

The Cutting up of Scrap Steel with Oxygen due to the Higher Metal Value has developed very rapidly in the last two years. Prior to that time the cost of cutting was hardly warranted by the price that could be obtained for the scrap metal.

Armour-Plate Cutting.—This is being done very extensively, hydrogen being generally used as a heating gas. Heavy cutting of this sort is mostly carried out by a small machine called the "Radiagraph," Fig. 5, annexed, which carries a motor, driving through a variable-speed gear two of the wheels, a third wheel being of castor type, so as to allow for steering. This device carries a cutting torch and can be steered over the plate which is to be cut by means of a small hand-

wheel, or the machine can be used on the end of a trammel cutting a circle from a centre where the cutting is in a straight line. It can be used, as well, on guide rails which are laid on the work, or the rails can be supported above the work in such a manner as to allow the cutting to be carried out. The torch can be swivelled in any direction so as to allow for a bevel to be cut. This device has been used for cutting port holes in armour plate, and a large amount of similar work, and has effected a remarkable saving.

Acetylene Generators of the "water-to-carbide" type and made on the flooding principle, so commonly used in Europe, have never found favour in the United States, owing largely to the regulations of the Board of Fire Underwriters. The use of "carbide-to-water" generators is practically universal.

The terms "low-pressure" and "high-pressure" systems do not mean the same in the United States as in Europe, where the names refer to whether the gas is taken from low-pressure generators or from dissolved-acetylene tanks, the latter being, of course, called "high pressure." In the United States the terms refer to the type of mixing device embodied in the torch, and not to the source of supply of gas. The type, in which the oxygen under a considerable pressure draws in, by injector action, the acetylene which is under only a few ounces pressure, comprises the "low-pressure" system. Sometimes torches of this description will be used with acetylene up to about 2 lb. pressure, the principle being practically the same as when only using a few inches of water pressure. Torches of this class can obtain their acetylene from a generator either of the "high-pressure" or "low-pressure" type, or from a dissolved-acetylene tank. The "high-pressure" type has the pressure of the oxygen and acetylene more nearly uniform, the acetylene being under sufficient pressure so as not to require the injector action of the oxygen to cause the mixture. The most popular type of torch has a mixing device in which the oxygen and acetylene are driven together at right angles by their own pressure in a detachable tip, thus producing the maximum vortex; this results in a very thorough mixture and a close approximation of the theoretical correct proportion of one part of oxygen to one part of acetylene required to produce the reaction to carbon monoxide, which is the only part of the flame used in welding; the balance of oxygen required to produce complete combustion is taken from the air. The acetylene in this case cannot be taken from a low-pressure generator. Either a high-pressure generator working up to 15 lb. per square inch or dissolved acetylene is used, and owing to the lower cost of the former method it is adopted wherever possible for stationary work. Dissolved-acetylene cylinders are used almost universally for portable requirements portable acetylene generators being prohibited by the insurance authorities.

Lack of skilled operators has greatly retarded the development of the industry in the United States, because there is no systematic method of instruction as in France, Germany and Great Britain. The larger firms selling apparatus give a small amount of instruction free. This is necessarily limited, however, merely to defining the fundamental principles, and instruction is given at a time when the student has not sufficient knowledge of the process readily to absorb it. The price charged for the apparatus does not warrant a large expenditure by the manufacturers for this free instruction.

Other operators are developed from helpers around the welding shops. The practice necessary to produce skilled welders must then necessarily be obtained on productive work, with the result that the general standard of work is lowered, and the industry suffers thereby. There is no doubt that the industry would expand by leaps and bounds if some system of producing skilled welders were developed; and it would be a great advantage if these welders could be also skilled in the various trades in connection with which they work, as there are big advantages for a boiler welder to be also a first-class boiler maker, a welder in connection with machine-shop work to be a machinist, and likewise in the other trades.

RAILWAY ARTILLERY.*

By Colonel JAMES B. DILLARD,† U.S.A.

CONTRARY to general belief, railway artillery is not a recent development of ordnance. In 1863 a 13-in. mortar was used by the Union Army against the defences of Richmond. It weighed 17,000 lb., and was mounted on a flat car having eight wheels. Some 4-in. artillery pieces were also used on railway mounts. In 1883 General Joseph L. Brent wrote a book on the subject of railway artillery, in which he prophesied accurately its development as has occurred during the European war, and even anticipated the armoured automobile and the tank. Both the British and Boer forces in the South African war utilised naval or coast-defence guns on railway cars. In the campaign for the relief of Ladysmith the British used four 12-lb. naval guns on flat cars. Armoured trains, mounting field guns, were also used.

In 1893 the Schneider Company, of France, brought out a type of disappearing carriage mounted on wheels for road transportation. The St. Chamond Company, of France, brought out a similar design, but mounted upon a railway car. The weight of this 4·7-in. gun and mount was about 20,000 lb.

In 1900 the Schneider Company made up a 155-mm. howitzer mounted upon a car which closely resembles the design used to-day. The Skoda Company, Austria, brought out a design of truck mounting to secure greater mobility for light coast-defence guns calculated to travel a short distance only.

A few years later the St. Chamond Company had improved its 1892 model, the gun still having a disappearing carriage, but well mounted on a short railway truck equipped with rail camps to secure increased stability under firing strain. It had also a horizontal armoured shield overhead for the protection of the gunner. Since then it has been found that the rail clamps are suitable only for guns smaller than 6 in., as heavy guns pull the rails and ties out of the roadbed.

About this time the Krupp works in Germany built a 4·7-in. railway gun which was simply a wheeled road gun with disappearing carriage placed on top of a flat car. Rail clamps and outriggers appear in this design; the latter consist of swinging brackets with vertical hinge pins and jack screws at the outer ends, and serve for bracing the car during firing.

In 1912 the Schneider Company brought out a design for a 200-mm. howitzer which is now typical of our present ideas for mounting guns up to 8 in., and mortars up to 12 in. The howitzer is mounted on the usual type of barbette carriage, in that it can fire in any direction, and is placed upon a drop-frame car. A folded platform is used, also outriggers. Fig. 1 (*g*)* shows an American design of about 1912 for a 4·7-in. howitzer, which is very similar to the Schneider.

In the foregoing cases the main object was to devise a mobile weapon for coast defence, but in the European war the use of railway artillery was confined to field operations, no coast-defence necessities having arisen.

Types of Cannon Used on Railways.—The types of cannon mounted on railway cars are the same as those used in field and sea-coast artillery, and include mortars which are 9 calibres to 12 calibres (diameters) long; howitzers, 15 calibres to 20 calibres long; and guns which vary in length from 30 calibres to 50 or more calibres. Mortars are used for "plunging fire"—fired at angles of elevation of 45 deg. to 65 deg., the projectile dropping nearly vertically on its objective. The mortars used by the American Army are of 12-in. bore, 9 calibres to 15 calibres long, and their muzzle velocity ranges from 900 ft. to 1,800 ft. per second. On railway mounts they can be fired at angles of 20 deg. to 65 deg. The weight of projectile is 700 lb., and the maximum range is 15,500 yards. The modern trend is to abandon the mortar, because its only advantage is that it is cheaper and will perform certain functions as well as the howitzer. Howitzers are fired at angles of elevation from 30 deg. to 65 deg. The American Army uses howitzers of 6-in. to 16-in. bore, having a muzzle velocity of from 1,500 ft. to 2,000 ft. per second. Only the 16-in. howitzer has been mounted. It fires a 1,600-lb. projectile with a muzzle velocity of 2,100 ft. per second, which, at a 45-deg. elevation, gives a range of about 24,000 yards.

Guns are used for accurate work at long range. The German guns which bombarded Paris were doubtless 60 calibres to 70 calibres long. Until the present war, guns were normally used for direct fire at elevations not exceeding 20 deg. Recently, however, they have been used at elevations up to 45 deg., to obtain the maximum range possible.

Accuracy of firing at these high elevations and long ranges is, however, small, as the German gun required a target of the size of the city of Paris, and was not always able to hit even that. The range of the guns in our service, which vary from 8 in. to 14 in., is from 13 miles to 30 miles. The projectiles vary in weight from 200 lb. for the 8-in. gun to 1,400 lb. for the 14-in.

The accuracy life of the mortar is estimated to be about 5,000 rounds; of the howitzer, about 2,000 rounds; and of the gun, about 150 rounds. After firing this number of shots, the fire becomes inaccurate owing to the wear in the barrel.

Problems of Design.—The two main problems in the design of railway mounts are transportation and provision for stresses due to gun-firing. The transportation problem requires that the closest consideration be given to weight, minimum railway clearances, and a full understanding of car design, especially as pertains to the trucks. To handle mounts weighing 600,000 lb. and upward a system of trucks must be utilised that combines perfect equalisation of loads and flexibility.

The condition of road beds in France has limited all axle loads to not over 17 metric tons. For mounts designed for use only in the United States this might be increased to 22 tons, but so far all the railway mounts, with the exception of the 8-in. gun, have been limited to the maximum weight allowed by the French railways.

The railway clearances set up by tunnels, bridges, third rails, &c., present a considerable handicap and impose several limitations upon the design. Fortunately, American and French line clearances differ very little and provide for a maximum height of about 14 ft. at the centre of the track and a width of 10 ft. Fig. I, on page 174, shows on the right the French, and on the left the American, clearance diagram for the 8-in. gun railway mount. The American Army has made a study of the clearance diagrams of all United States railways to insure that all our mounts will be capable of being used in any part of the country. With guns up to 8 in. and howitzers up to 12 in., the limitations to design set by the railway clearances are slight, but in the case of howitzers of 16 in. and up, and with guns 12 in. and up, the limitations of the clearance diagram begin to be severely felt.

The gun is elevated around its trunnions, which are usually located at the centre of gravity of the tipping parts. The breech end of a 12-in. gun when tilted around its trunnions would strike the cross-ties at bout 30 deg. elevation, 25 deg. elevation for the 14-in. gun, and a less elevation for the 16-in. gun. In order to secure a greater elevation it is necessary to modify the design by any one of the following methods: The gun is artificially thrown out of balance by placing a weight at the breech end. A mechanical counterbalance device, such as springs or compressed air, can also be used. In this case a column of springs or a compressed-air column is so lined up with the elevating gear as to compensate for the muzzle preponderance when the trunnions are located to the rear of the centre of gravity of the gun. A third method is to provide a top carriage carrying the trunnions of the gun and to raise this sufficiently high into firing position by means of hydraulic jacks to enable the breech to clear the ties.

The fourth but least desirable method is to dig a pit in the line of the railroad track, but this requires a specially constructed track to bridge over the gap caused by the excavation, besides there may not be time available to make the excavation especially when the ground is frozen. All of these alternatives have been utilised in the various designs of railway mounts, but the simplest and best is the use of the counterweight, as there are no moving parts involved.

In providing for stresses due to gun-fire, it must be remembered that the mounts should permit of elevation up to 45 deg. in order to secure the maximum range obtainable. The widest possible traverse should be aimed at, 360 deg. if possible. It is comparatively easy to obtain the elevation desired, except with the 16-in. size and upward, but it is not possible to obtain more than about 10 deg. total traverse with the railway mount unless considerable time is allowed for preparing a firing platform other than that provided by the car itself.

For guns up to 8 in., and howitzers and mortars up to 12 in., an especially designed drop-frame flat car can be used and the barbette carriage of standard construction placed upon the car. Fig. I shows the 8-in. gun railway mount, model 1918, as designed by the Ordnance Department.

With larger guns various designs have been produced for use in the present war. Most of them provide for a 2 deg. to 6 deg. traverse on either side of the centre of the gun, greater change of direction being obtained by using the curved track. Even this arrangement places a handicap upon the tactical uses to which these guns may be put.

Barbette Carriages for All-around Fire.—These carriages are of the standard barbette type. In fact, the carriages may be removed from the flat car and mounted upon a concrete base as is the practice in many of our sea-coast forts. The carriages are always provided with recoil and counter-recoil mechanisms. The force of recoil is checked by forcing a liquid in the recoil cylinder, usually oil of about 0·85 specific gravity, through two or more orifices cut in a piston, the piston rod being attached to the breech of the gun, while the recoil cylinder is attached to the cradle.

Counter-recoil is accomplished by means of helical springs, usually about four columns, or by means of compressed air contained in an air bottle located above the centre line of the gun. The 8-in. gun carriage has a spring counter-recoil mechanism as shown in Fig. II, page 174, while the 12-in. mortar carriage has the compressed-air counter-recoil mechanism (air recuperator) illustrated in Fig. III, page 175.

With the larger guns compressed air is preferred on account of the less bulky mechanism required. Figs. II and III show also the type of elevating mechanism used, which includes a worm and worm-wheel sector. The traversing gear consists of a turntable resting on conical rollers, which in turn rest upon a bedplate attached to the body of the car.

The design of limited-traverse railway mounts for guns and howitzers presents but few engineering difficulties. The principal one relates to the height at which the trunnions must be placed in order that the breech of the gun may not interfere with the road track. Fig. 1 (*b*) is typical for this type. The trunnion of the gun rests upon girders which are supported at each end by trucks. It is evident that by means of the curved track a reasonable amount of traversing is available.

In the case of the all-around firing type of mount for large guns and howitzers, it is necessary to have some form of firing platform on account of the varying direction in which the firing stresses may act.

During 1915, the Ordnance Department started the design of the 14-in. mount, Model E, shown in Fig. 1 (*b*). A base ring with a conical roller path is carried in a separate car, and is to be set into the ground. The gun and mount on its travelling trucks are run over the base ring so that the centre of the car is over the centre of the base ring. The mount is then jacked up so that the travelling trucks may be disengaged from the girders. The mount is then lowered so that it rests upon the conical roller path, where it is free to be traversed in any direction. This arrangement has also been applied to the construction of a 16-in. howitzer railway mount.

Foreign Types of Railway Artillery.—A number of French howitzers have proved very satisfactory during the present war. They include the 190-mm. (7·6-in.) and the 240-mm. (9·6-in.) howitzer railway mounts with movable top carriages. These mounts are not provided with a traverse mechanism, and therefore must be moved along a curved track to obtain azimuth setting Due to the lack of long-range field artillery at the beginning of the war it became necessary for the French Government to construct with the greatest of rapidity considerable quantities of railway artillery, and to utilise naval and coast-defence guns already in existence.

* Lecture, with slides and motion pictures, delivered at the annual meeting of the American Society of Mechanical Engineers, New York, December 5, 1918.

† Engineering Division, Ordnance Department, Washington, D.C.

* We have not reproduced the photographic illustrations, although here enumerated as Fig. 1*a* to *j*. The Figure Numbers of the drawings reproduced are given in Roman Figures alike in the paper and illustrations.

Schneider and Co. then designed what they termed a "glissement" or sliding railway mount, an example of which is shown in Fig. 1 (*b*).

These mounts consist of two six-wheel or eight-wheel railway trucks connected by heavy girders which carry the weight of the gun. These girders are provided on the lower surface with cross-beams connected to the girders by jack-screws. Before firing, these cross-beams are lowered on firing rails, thus relieving the trucks of the firing load, which is transmitted directly to the road bed. No recoil mechanism being provided, the floats prevent the car from recoiling along the track. The shock of recoil is absorbed by hydraulic cylinders, and the gun is returned to battery by an air-recuperator. The top carriage can traverse about 2 deg.

The 14-in. British railway gun is almost identical in design with Fig. 1 (*c*). The gun is 62·5 ft. long, weighs approximately 183,000 lb., and is mounted in a cradle whose trunnions are supported by two longitudinal girders carried on two sets of four-axle trucks. The total weight of this mount is approximately 545,000 lb. With this gun a traverse of 2 deg. on either side of the Ordnance Department for similar sizes of guns and mortars, and provides for 360 deg. traverse. Fig. 1 (*j*) shows the construction of this type of mount. The trucks used are Pennsylvania Railroad standard 70-ton freight-car trucks. A firing platform and outriggers are necessary to brace the mount against the ground to take up firing stresses. Each outrigger consists of a pipe attached by a ball-and-socket joint to the car frame, the lower end having a screw jack which rests on the wooden float sunk in the ground. The jacks for raising and lowering the car are built in the structural part of

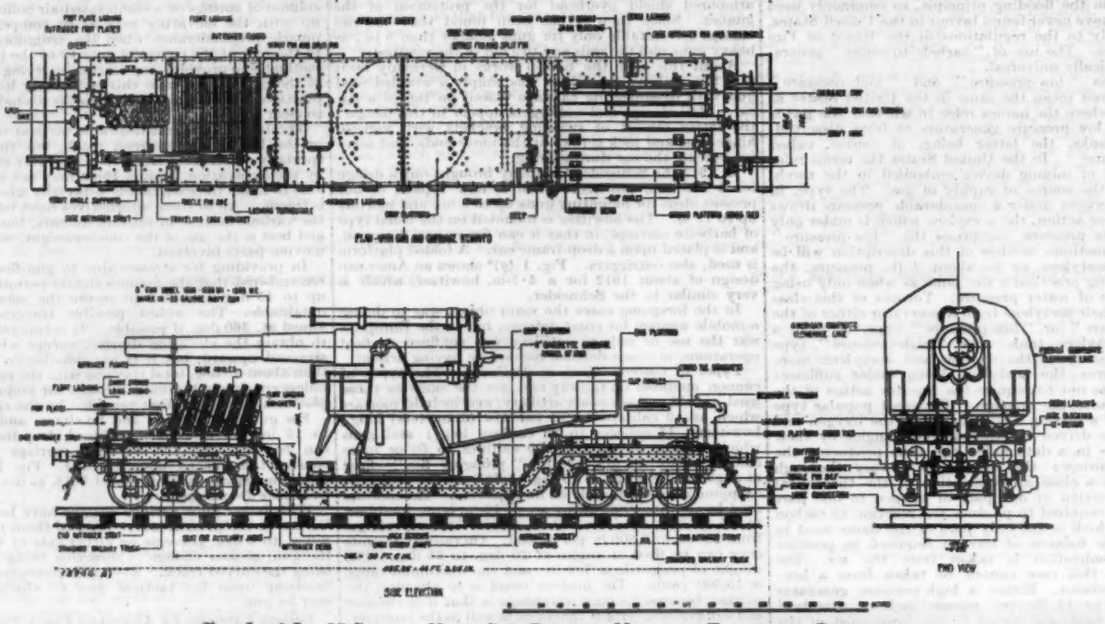


FIG. I. 8-IN. 35-CALIBRE NAVY GUN RAILWAY MOUNT IN TRAVELLING POSITION.

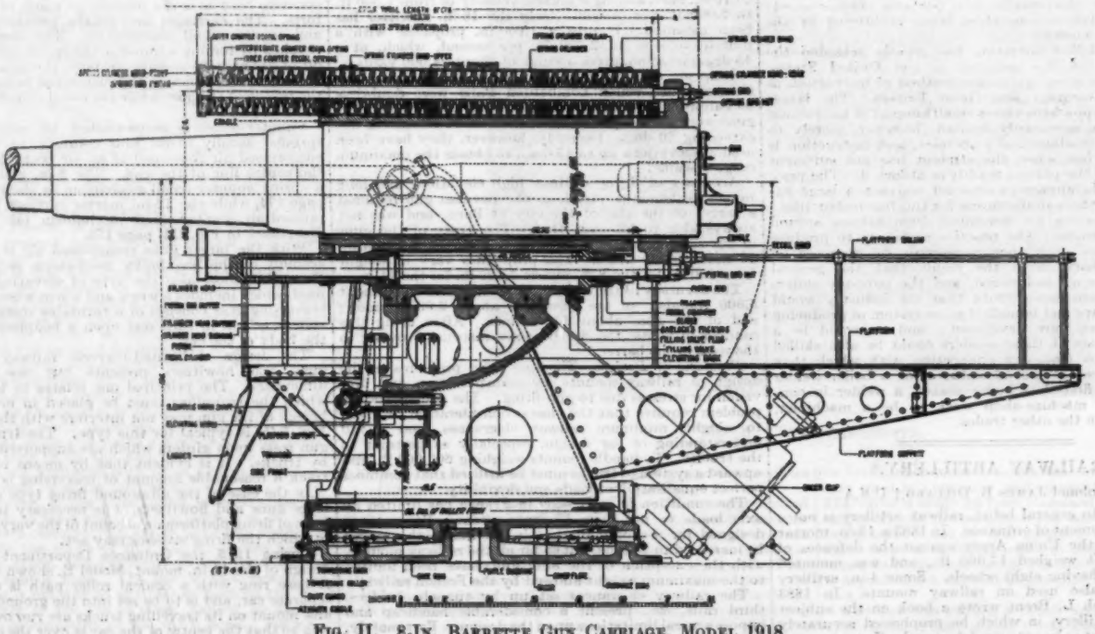


FIG. II. 8-IN. BARBETTE GUN CARRIAGE, MODEL 1918.

recoil force is taken up by the friction of the entire mount sliding backward on the firing rails.

No traversing mechanism is provided, direction in azimuth being obtained by constructing the firing track on a curve. After the shot is fired, it is necessary to move this gun forward to its original position, which is done by hand through a system of sprockets and chains to turn the wheels of the trucks.

Fig. 1 (*c*) shows a 340-mm. (14-in.) railway gun built by St. Chamond. The gun rests in a cradle, which is a large ribbed casting through which the gun slides in recoil. The cradle has trunnions which are carried in trunnion bearings on the top carriage, which is supported by the car frame mounted on trucks. The firing emplacement consists of a pit into which the gun recoils when firing at higher angles. Two platforms which act as a foundation for four jacks provided with large timber centre line is provided for. In order to secure a high elevation the gun is placed forward in the cradle so that it has a considerable amount of muzzle preponderance. This unbalanced weight is compensated by a pneumatic counterbalance device so that the piece may be easily elevated. The recoil mechanism consists of two hydraulic cylinders, and the gun is returned to battery by a pneumatic cylinder. The elevating mechanism consists of a screw operated by a gasoline engine.

American Types of Railway Artillery.—Fig. 1 (*e*) shows a barbette carriage mounting a 7-in. 45-calibre gun, a design developed by the Ordnance Department. The carriage and gun were originally designed by the Navy Department, and were mounted on certain battleships and cruisers. A number were available for army use, and were mounted on the railway car with drop-frame as shown. This car construction is now a standard with the the frame and are operated by ratchet levers. The total vertical movement required for the insertion of the oak cross-ties in the firing platform is about 1 in. The mount may be put in firing position by a gun crew in 15 minutes to 20 minutes.

The 1918 model 8-in. gun railway mount, which uses the same barbette carriage as the 7-in. gun, Fig. 1 (*e*), may be elevated from 0 deg. to 42 deg. It fires either a 200-lb. or 300-lb. projectile at a maximum muzzle velocity of 2,000 ft. per second, and has a maximum range of about 23,000 yards.

By means of special eight-wheel trucks it is possible to transport this mount over a 60-cm. (24-in.) narrow-gauge track. This 8-in. mount weighs about 180,000 lb., and it certainly is a great advantage to be able to transfer it to a narrow-gauge track, which is the kind used at the battle front in order to better conceal operations. On

the narrow-gauge track a speed up to 15 m.p.h. is feasible. The Ordnance Department, who developed this mount in its entirety, considers this artillery piece to be the last word in railway mounts. It is also the only mount of its kind in existence.

Fig. 1 (*a*) shows a 12-in. mortar placed upon the same car as the 7-in. and 8-in. guns, except that six-wheel trucks are used in place of the standard 70-ton four-wheel trucks. It is also adapted for narrow-gauge track, and makes a highly satisfactory piece for field and sea-coast work.

Fig. 1 (*b*) represents also the American sliding type of railway mount. It has neither recoil mechanism nor travelling mechanism. It is a 12-in. gun, and the entire mount is about 105 ft. long and weighs 575,000 lb. It can be transported at the rate of 40 miles an hour over standard-gauge road bed, and will go around any curve met with in American or French railway practice. When the gun is to be used, the track is laid on a curve and the gun is turned on its objective by moving the mount back and forth by means of a gasoline engine. A special hand-translating mechanism is used for spotting the mount in the exact position.

The principal parts of the car body consists of bridge girders, span bolsters connected to eight-wheel trucks, trucks bearing stringers and sleepers, lifting wedges and loading mechanism. The gun is supported on trunnion beds, which are carried on top of the girders. The gun can be elevated from — 4 deg. to + 40 deg. The slippers consist of wooden beams placed crosswise under the car body, supported by th elevating wedges which raise and lower them into position. The bearing stringers are made up of eight lines of 12-in. steel I-beams. The lifting wedges are operated by handles, one man being placed at each handle. No special track preparation is necessary other than to lay the stringers and to see that the track is well ballasted. In the firing the entire piece slides to the rear for about 15 ft., and after each shot the mount is returned by means of the power winch and the hand-translating device. The 12-in. gun used is 50 calibres in length, and is one of the most powerful in existence. The muzzle velocity is 3,200 ft. per second, and the range is approximately 30 miles.

Fig. 1 (*a*) illustrates what is considered the very latest type of railway artillery. This mount carries the 16-in. howitzer developed by the Ordnance Department in 1918, which is the most powerful howitzer known. The carriage embodies the features which are considered the most desirable in handling railway artillery for field army use. The howitzer can be fired on this mount directly from the trucks on standard-gauge track. The track emplacement and bearing stringers to take up the shock of recoil are done away with. The shock of fire is taken care of in the recoil, and in pushing the car backward along the tracks on its own trucks. For this duty unusually heavy trucks are necessary to absorb the shock and to transmit it to the road bed. The piston-rod pull is approximately 670,000 lb., which force is transmitted directly to the trucks. Two twelve-wheel trucks are used with specially-designed frames and springs. The top carriage is pivoted at its forward end, and arranged at its rear end so that 12 deg. traverse is all that is necessary for range correction, the range direction being secured by running the mount on a curved track. A gasoline winch is placed on the forward trucks which pulls the mount back to its original position by means of a cable attached to a rail clamp. Four columns of counter-recoil springs are used. The loading arrangement is the American style of gravity platform, which permits the projectile to slide into the breech.

Fig. 1 (*b*) illustrates the 14-in. Navy gun railway mount built by the Navy Bureau of Ordnance. Some 14-in. 50-calibre guns that were not required aboard ships were utilised and mounted on railway trucks Four six-wheel trucks are used and connected by span bolsters upon which rest the body girders. Top girders support the gun and its cradle by means of the usual trunnion and bedplate. A cab, consisting of ¼-in. armour plate, encloses the body girders, as well as the breech end of the gun. The emplacement, of structural steel, is carried on special cars and is placed in position by a locomotive crane. Four jacks are used to relieve the trucks of the firing shot. Five degrees traverse is secured in place, and 45 deg. elevation. This amount of elevation necessitates a pit of 9 ft. in depth.

Auxiliary Cars.—All railway artillery operates in batteries which are made up of four gun mounts with their auxiliary cars, including ammunition cars, fire-control cars and supply cars. The ammunition car is especially designed and standard for all railway artillery. It is a steel car provided with a trolley I-beam and hoist for handling ammunition. The ammunition is stored in racks, which are so arranged that they can be taken down and the car used as an ordinary box car. The fire-control car is a standard Government 30-ton box car provided with windows. It is used as an office by the battery commander and contains fire-control instruments. The supply car is a standard Government 30-ton flat car, on which is carried the auxiliary equipment and the supplies that are to be used with heavy railway artillery.

Tactical Uses.—The uses for railway artillery are considered under two principal heads, namely, against land targets with field armies; and for coast defence. Guns, howitzers and mortars are required for these purposes.

For use with field armies the ability to bring the mount into and away from the firing position is of more tactical value than an extremely wide traversing angle without moving the location of the gun. On the other hand, for sea-coast defence a wide, quick and accurate traverse without changing the location of the gun mount is an absolute essential. One of the greatest values which railway artillery can have to the United States is the ability to concentrate large numbers of guns within any given strategic area. If guns are made up in trains, they can be moved quickly from one place to another, therefore, considerable economy will be obtained in securing proper protection for any part of our coast line and for any harbour.

In the present war railway artillery was used for the following kinds of fire: (*a*) Fire for destruction; (*b*) fire of interdiction; (*c*) counter battery work; and (*d*) reprisal bombardment.

Fire for destruction includes the demolition of railway centres, depots, fortified works, bridges, &c. For this work high-angle or plunging fire is desirable in order that the projectiles may bury themselves in the ground before exploding, thus causing a large crater to be formed and securing the maximum amount of destruction. For this kind of fire the use of howitzers and mortars is indicated. If it is required to obtain a number of direct hits on a small target at a range of 20,000 m. to 25,000 m., it would be better to use a considerable number of total rounds which can be obtained economically with guns having a long accuracy life, namely, howitzers and mortars. Beyond the range of howitzers, guns must be used. Rapid firing not being essential, the sliding type of gun mount is entirely satisfactory.

Interdiction firing includes destruction and interruption of traffic on lines of communication. It may be desirable to keep certain sections of a railway line out of commission or to shell sections of some important road over which supplies of men must move. In this case the target is usually small, and therefore greater accuracy of fire is necessary. As time is required to repair the damage, intermittent shelling will suffice. Two to four well-placed shots a day are sufficient to keep a railway line out of commission. For this work, therefore, it has been the practice to use very long-range guns with a sliding type of railway mount.

Counter battery work includes the destruction of such enemy batteries as are out of range of the army artillery. The army artillery consists of guns of about 6-in. calibre and howitzers of about 9·5-in. calibre. The range is 15,000 m. to 18,000 m., whereas all railway artillery should have a minimum range of about 23,000 m., and preferably 25,000 m. or more. A very wide traversing angle is essential on account of the probably wide variations in the position of the enemy batteries which must be reached quickly. An 8-in. gun is best for this class of work mounted upon a carriage similar to our 8-in. barbette, model 1918, previously described.

Reprisal bombardment requires the use of long-distance guns, such as the German gun which shelled Paris. This gun was not, however, mounted upon a railway carriage. A sliding type of mount, combined with a recoil mechanism, would seem to be the proper mounting.

For use against heavy concrete fortifications a howitzer such as the 16-in. would be proper, as a smaller size would probably fail to have the desired destructive effect, but for the destruction of a railway bridge the use of a 16-in. howitzer would be very wasteful, as a direct hit from an 8-in. gun would be about equally effective for destroying the superstructure.

Lessons of the War.—The value and economy of sea-coast defence has been completely demonstrated in the present war. The absolute protection afforded the German coast line on the North Sea and the completely successful defence of the Dardanelles are the most striking examples. Considering the fortifications of the Dardanelles only, it is undoubtedly a fact that the coast defences established there had a value to the Central Powers of many billions of dollars. In fact, it can hardly be contradicted that, had these fortifications been forced, the resistance of the Germans would have been broken long before was actually the case. Their military value was a hundred times their actual monetary cost. It is also probable that, had the guns at the Dardanelles been mounted on railway carriages of suitable design and had comparatively inexpensive railway tracks been laid to important tactical points, it would have been almost impossible for landing parties in any force to have succeeded in effecting their object. This lesson as to the value of sea-coast defences is of the utmost importance to us, because our coast line is so extended that the cost would be considered prohibitive if adequate, fixed fortifications were to be furnished for all points whose strategic position would apparently justify such defences.

The present state of the art of artillery design is such that guns and howitzers having a range of 22,000 m. or more are of such weight and exert such forces due

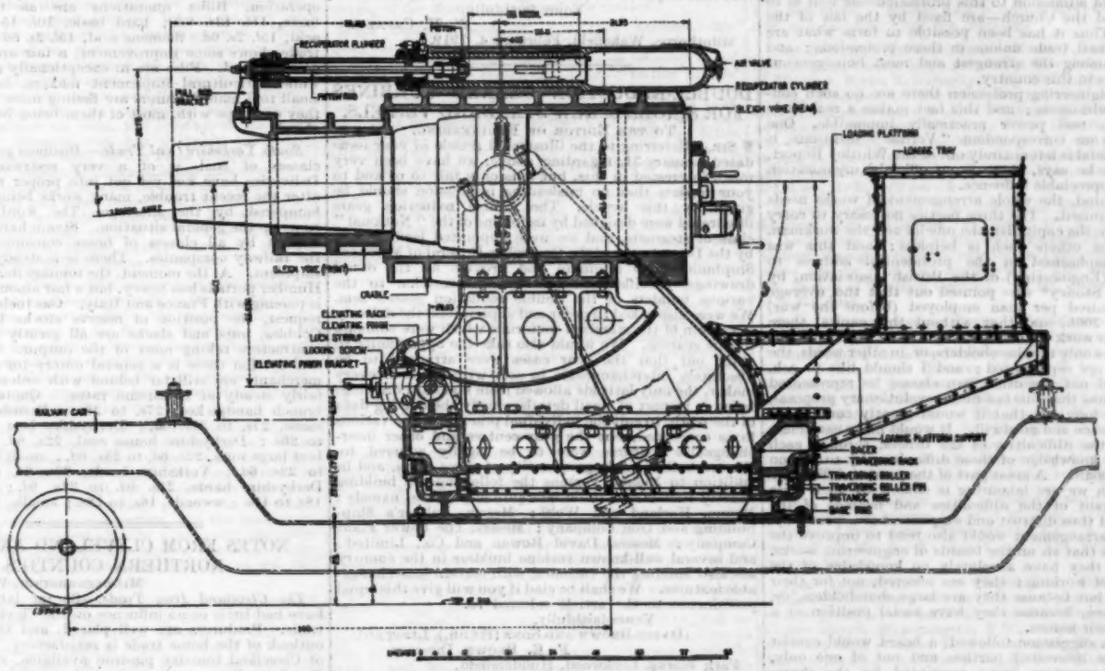


FIG. III. 12-IN. BARBETTE MORTAR CARRIAGE, MODEL 1918.

to the firing of the gun that they must be mounted either on fixed carriages or on railway cars. However, in the immediate future it is evident that guns mounted upon self-propelled caterpillars will appear, and probably within the next few years railway artillery will be limited to guns of 10-in. calibre and up, and howitzers of 16-in. calibre and up. The development of this caterpillar artillery was begun by the Ordnance Department about three years ago, and successful types have been built for 7·5-in. guns and for 8-in. howitzers. The next step will be the substitution of the caterpillar treads for the railroad trucks in mounts such as the 8-in. gun and 12-in. mortar.

THE POSITION OF THE OFFICIAL IN ENGINEERING AND OTHER WORKS.

TO THE EDITOR OF ENGINEERING.

SIR,—I am much interested in the letters on this subject that have appeared in your issues of January 17 and 31, following my letter of December 20, 1918. There is evidently a common agreement that employers have not acted fairly by their officials; and the question is, What should be done?

One method would be to form a trade union or the equivalent among officials; but all experience goes to show that such an organisation is not possible among educated men—at least, not such a union as to have any real power. An instance often mentioned of a combination between educated men is that of the medical profession; but this instance scarcely applies, for the conditions of admission to this profession—as well as to the law and the Church—are fixed by the law of the country. Thus it has been possible to form what are really legalised trade unions in these professions; and these are among the strongest and most homogeneous trade unions in this country.

In the engineering profession there are no such conditions of admission; and this fact makes a real trade union with real power practically impossible. One result, as your correspondent "Veritas" mentions, is that the official is left entirely out of the Whitley Report, because, as he says, there is no officials' organisation with any appreciable influence.

To my mind, the whole arrangement of works needs to be reorganised. The three parties necessary to carry on works are the capitalist, the official and the workman. Without the others each is helpless; and this was strongly emphasised in the presidential address to Section G (Engineering) of the British Association, by Mr. Gerald Stoney* who pointed out that the average capital required per man employed (before the war) was about 200*l.*, and that without this capital there would be no work for the working man. On the boards of companies only the shareholders, or, in other words, the capitalists, are represented; and I should like to ask, Why should not the other two classes be represented also? I know that this is a most revolutionary proposal, but I have long felt that it would greatly conduce to industrial peace and goodwill. It would make each class appreciate the difficulties of the others, through each gaining full knowledge of these difficulties by sitting on a common board. A great part of the present difficulties under which we are labouring is caused by each class being ignorant of the difficulties and feelings of the others; and thus distrust and suspicion have sprung up.

Such an arrangement would also tend to improve the type of men that sit on the boards of engineering works. Too often, they have absolutely no knowledge of the conditions of working; they are selected, not for their suitability, but because they are large shareholders, or, in some cases, because they have social position or a handle to their names.

Were this suggestion followed, a board would consist of the three interested parties, and not of one only, a certain proportion being appointed by the shareholders, another by the officials, and a third by the workmen. A legal enactment should make it impossible for any company to exist without this arrangement. Thus each class would have full cognisance of the affairs of the company and the difficulties that arose.

I know that there are many difficulties in the way of carrying out such a suggestion as this; but they could be overcome. If the method were fairly and honestly brought into force it would largely tend to bring about industrial peace, instead of the industrial war that now exists.

Yours truly,
"EX-OFFICIAL."

February 3, 1919.

"COAL SAVING BY THE SCIENTIFIC CONTROL OF STEAM BOILER PLANT."

TO THE EDITOR OF ENGINEERING.

SIR,—The letter of your correspondent which appeared on page 139 of ENGINEERING, of the 31st ult., I have read, with mixed feelings, as it leaves one in doubt as to whether the writer is serious or trying a new method of leg pulling. Unless I have quite misunderstood his comments, they are quite opposed to present-day practice.

In Mr. Brownlie's report as given in your issues of July 12 and 19 last year, we find that with the 1,000 boilers tested, the average CO_2 was 7·6 per cent., and which indicates 30 lb. of air per pound of coal and a furnace temperature of 1,700 deg., the evaporation per square foot of grate being 137 lb. The report in question and the letters supporting it to which your correspondent refers were not based on theory, but practical results, and all pointed to the fact that reducing the air supply per pound of coal increased the furnace temperature and consequently the duty and efficiency of the boiler.

Your correspondent infers his comments are based on observation made twenty years ago, but the same law applied then as now, *i.e.*, that the duty and efficiency of a boiler is gauged by the distance between the initial and terminal temperature of the furnaces and gases.

To burn 1 lb. of coal, 12 lb. of air is required, but the temperature is too high for steam-raising purposes; but 50 per cent. excess air, which makes a total of 18 lb. of air per pound of coal, gives a good practical working temperature of 2,700 deg.; but 120 per cent. to 140 per cent. excess air, as mentioned by your correspondent, reduces the temperature to less than 2,000 deg., simply because it gives 28 lb. of air per pound of coal instead of 18 lb.

If we now work a boiler with a coal and air mixture of 1 to 18, the initial temperature is 2,700 deg., and assume its terminal temperature as 700 deg.—the range being 2,000 deg.—the heat leaving the boiler with the gases is 3,024 British thermal units, but if we work the boiler with 28 lb. of air per pound of coal the gases, we will assume, leaving the boiler at 600 deg.—a range of 1,400 deg.—the heat escaping with the gases is 4,032 British thermal units. The above figures, I think, will satisfy the writer of the letter in question that 50 per cent. excess is both more efficient and gives a higher duty than the figures he gives.

Mechanical draught, which is also referred to in the letter is more scientific than natural draught, and a boiler's duty can be readily increased 25 per cent. by its adoption, the cost of running the fan being less than half that required for producing natural draught.

Yours faithfully,
W. H. CASMEY.

Milnthorpe, Wakefield, February 4, 1919.

* See ENGINEERING September 8, 1916.

DOUBLE-REDUCTION GEARED TURBINES FOR SINGLE-SCREW STANDARD VESSELS.

TO THE EDITOR OF ENGINEERING.

SIR,—Referring to the illustrated article in your issue dated January 31, regarding above, we have been very much interested in this, but it is only fair to us and to your readers that no misleading impression should be given by this article. The double reduction gears illustrated were designed by us for one of the "National" class of steamers, and we were appointed leading firm by the Department of the Controller-General of Merchant Shipbuilding to originate and provide all the detail drawings, specifications and full information to the various builders of the double reduction geared sets. We were also asked to order and superintend the delivery of certain of the standard materials which were common to this gearing. We would also take the opportunity to point out that the gear cases were arranged to be absolutely interchangeable in sets with those of every maker, the only latitude allowed from standard drawings being in respect of small details, chiefly the cutting data of the teeth, to suit the individual practice of the various firms concerned, but the gear centres and other interchangeable features were to be rigidly adhered to. We are building a large quantity of these gears, and in addition to Messrs. Parsons the following are building exactly similar sets to designs provided by us, namely: Messrs. Harland and Wolff; Messrs. Palmer's Shipbuilding and Iron Company; Messrs. The Power Plant Company; Messrs. David Rowan and Co., Limited; and several well-known turbine builders in the country are also building the turbines, with certain interchangeable features. We shall be glad if you will give this equal prominence to the article referred to.

Yours faithfully,
(DAVID BROWN AND SONS (HUDD.), LIMITED).
F. E. BROWN, Director.

Park Works, Lockwood, Huddersfield,
February 3, 1919.

ELECTRIC WELDING.

TO THE EDITOR OF ENGINEERING.

SIR,—I have been requested to make a correction in regard to certain illustrations which appear in my paper on "Electric Welding," read on January 24 last before the Institution of Mechanical Engineers.

In the appendix to my paper the following occurs: "Fig. 10 and Figs. 11 and 12, Plate 3, show the work of the Kjellberg system with metallic electrode." The figures themselves also bear the title "Kjellberg System." These particular illustrations were lent to me by the British Arc Welding Company, Limited. The company named request me to say that the system of electric welding used by them is not the Kjellberg system, although a coated metallic electrode is used. It is the company's own system.

I shall be much obliged if you would, therefore, publish this statement in your next issue to avoid any possible misunderstanding.

Yours faithfully,
T. T. HEATON.

The Steel Barrel Company, Limited, Phœnix Wharf,
Uxbridge, Middlesex, February 5, 1919.

ROYAL INSTITUTION.—A general monthly meeting of the members of the Royal Institution was held on Monday last, February 3, Sir James Crichton-Browne, M.D., LL.D., F.R.S., treasurer and vice-president, in the chair. The chairman reported a bequest of 300*l.* from the late Dr. T. Lambert Mears, who was a member of the Institution for fifty-three years; and a donation of 50*l.* from "An Old Member," in celebration of his fiftieth year of membership. Mr. A. J. Walter, K.C., was elected a manager to fill the vacancy caused by the death of Sir Charles Norris Nicholson, Bart., M.P.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—So far no actual stoppage has occurred in the engineering trades of Sheffield, but there is grave unrest, chiefly owing to the delay of the National Executives in fixing up the detailed application of the 47-hour week. The Sheffield men are not satisfied with the 47 hours, and are agitating for a 40-hour week, but the most serious trouble is in connection with the night shifts, arrangements for shortening which are being held up pending the decision of the national bodies. The men have stopped all overtime, except on the most urgent maintenance work, failing local adjustment. The general trade position is unchanged, albeit a somewhat curious one. For material which can be supplied in plenty there is little demand, whereas in all the departments for finished steel products where the output is limited it is impossible to deal with a tithe of the orders received. On the one hand plant is standing idle, and on the other orders are being turned away. Crucible steel furnaces are working only moderately, and high-speed steel is almost a drug on the market. Enormous quantities have been in the hands of the national factories, and these will, in all probability, be now returned into manufacturers' stocks. Railway steel departments are full of work, though orders are being given with a certain amount of caution owing to the high prices current. Many of the open-hearth furnaces in the district are out of commission for the time. With the beginning of the month, the new steel prices came into operation. Billet quotations are as follows:—Soft basic, 11*l.* 12*s.* 6*d.*; hard basic, 10*l.* 15*s.*; Bessemer acid, 15*l.* 2*s.* 6*d.*; Siemens acid, 15*l.* 2*s.* 6*d.* The export trade shows some improvement, a fair amount of steel going abroad. Files are in exceptionally good demand, while agricultural implement makers, and engineers' small tool manufacturers are finding more business than they can cope with, most of them being booked months ahead.

South Yorkshire Coal Trade.—Business generally, in all classes of coal, is of a very restricted character. Deliveries have not yet got into proper running order after the recent trouble, many works being still greatly hampered by the shortage. The word "scarcity" sums up the general situation. Steam hards are in keen request by all classes of home consumers, especially the railway companies. There is a steady demand for shipment. At the moment, the tonnage dealt with at the Humber ports is less heavy, but a fair amount of business is passing with France and Italy. Gas fuels are in urgent request, the position of reserve stocks being serious. Cobbles, nuts and slacks are all greatly sought after, contractors taking most of the output. In the house coal section there is a general outcry for supplies, and merchants are still far behind with orders. Cokes are fairly steady at maximum rates. Quotations:—Best branch handpicked, 27*s.* to 28*s.*; Barnsley best Silkstone, 27*s.* to 27*s.* 6*d.*; Derbyshire best brights, 25*s.* to 26*s.*; Derbyshire house coal, 22*s.* 6*d.* to 23*s.* 6*d.*; best large nuts, 22*s.* 6*d.* to 23*s.* 6*d.*; small nuts, 21*s.* 6*d.* to 22*s.* 6*d.*; Yorkshire hards, 22*s.* 6*d.* to 23*s.* 6*d.*; Derbyshire hards, 21*s.* 9*d.* to 22*s.* 9*d.*; best slacks, 18*s.* to 19*s.*; seconds, 16*s.* to 18*s.*; smalls, 13*s.* to 14*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—So far labour troubles have had little or no influence on the Cleveland pig-iron trade. Producers are well placed, and the immediate outlook of the home trade is satisfactory. The quality of Cleveland foundry pig-iron available, and especially No. 3 quality, continues to fall considerably short of requirements. On the other hand, forge iron is quite plentiful, and is taken up to as large an extent as possible by pig-iron consumers, many of whom at one time would use nothing but foundry description. With furnaces working very indifferently, several producing little else than forge kind, and some even mottled and white, and most of them needing repairs or re-lining, the prospects of increased supply of the better qualities of iron are not bright. Practically all the No. 3 iron available is promptly taken up for home purposes. Trade with the Allies continues on only a moderate scale, and transactions with neutrals are still practically impossible. For home consumption, No. 3 Cleveland pig-iron, No. 4 foundry, and No. 4 forge all stand at 95*s.*, and No. 1 is 99*s.*; and for export, No. 3 and the lower qualities are 145*s.* and No. 1 is 150*s.*

Hematite Iron.—Slightly better account can be given of the East Coast hematite branch. Supply is rather better, and a fair amount of business is passing. There is sufficient iron for home needs, and it is reported that a little surplus is available for shipment abroad. Mixed Nos. are 122*s.* 6*d.* for home use, and 172*s.* 6*d.* for export.

Manufactured Iron and Steel.—There is less activity in certain departments of the manufactured iron and steel industries, due to labour difficulties. As was to be expected, issue of specifications for shipbuilding material show a marked falling-off. There is continued heavy demand for rails, constructional steel and galvanised sheets. The following are among the principal home quotations which become operative this month:—Common iron bars, 15*l.* 10*s.*; steel ship, bridge and tank plates, 14*l.*; steel ship angles, 13*l.* 12*s.* 6*d.*; steel boiler plates, 15*l.*; chequer plates, 15*l.* 10*s.*; steel joists, 13*l.* 12*s.* 6*d.*; heavy sections of steel rails, 13*l.* 10*s.* and billets and blooms, 11*l.* 2*s.* 6*d.* to 12*l.* 15*s.*

Shipments of Iron and Steel.—Pig-iron shipments from the port of Middlesbrough during January reached

31,381 tons, as compared with 28,513 tons in December, and 31,070 tons in November. Whilst in November and December considerable quantities were shipped to Scotland, in January only 1,370 tons went to coastwise ports, owing to the withdrawal of rebate upon shipments. Thus the foreign shipments in January amounted to 30,011 tons, compared with 22,306 tons in December, and 21,806 tons in November. Shipments of manufactured iron and steel last month totalled 18,080 tons, of which 16,315 tons went abroad. Pig-iron shipped to France last month amounted to 13,717 tons, and the quantity cleared for Italy was 10,144 tons.

Foreign Ore.—The new business passing in foreign ore is but small, for consumers are not keen buyers, and sales are not being pressed on the market. Users are carrying rather heavy stocks, and are regularly receiving very considerable imports in fulfilment of running contracts.

Coke.—Scarcity of coke is a little less pronounced, but better supply would be very welcome. Consumers are pressing for heavier deliveries to the blast furnaces, where reserves are stated to be very low. Average furnace coke is 33*s.* at the ovens, and low phosphorus quality 35*s.* 6*d.* at the ovens.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—The labour unrest and its consequent effect upon future movements in the steel trade are proving rather disconcerting, and the diminished output of the past week has not tended to any reassurance on the part of the manufacturers. With orders so plentiful, it certainly is unfortunate that anything should have occurred to limit or decrease production at the very time when the demand for material is so specially urgent and the claims of reconstruction pressing alike on employers and workers. Taking the position all over, the loyalty of the steel workers in the Glasgow area has probably prevented what might otherwise have been a total collapse of this most important industry. Shipbuilding material continues in great request, and with the increased maximum prices which have now come into effect, the speeding-up of output is more advisable than ever. For the home consumer a considerable variety of work is on order, while the reduction of freight charges opens up a vista of renewed activity with overseas customers.

Malleable Iron Trade.—The activity in the malleable iron works is undiminished, the bulk of the output being reserved for the home markets, the increase in rates being no real deterrent to the flow of business. Bars of all descriptions are much in demand, and sufficient work is in hand to keep all fully employed for some considerable time to come. Prices are all on the upward grade, and as 19*l.* 10*s.* per ton is now being quoted for export, shipments are not specially heavy.

Scotch Pig-Iron Trade.—While the demand for pig-iron is alike strong and steady, and smelters in full blast, an undercurrent of uncertainty makes itself felt. The supply of both hematite and foundry iron has appreciably increased, although it is not yet possible for any stock to be accumulated. Everything points to expansion and development in the near future. In the meantime, however, the home market absorbs, practically, the entire output, the present export rates having but little attraction for producers. All over the problem of the fuel supply gives rise to much anxiety.

Shipbuilding in Scotland.—As the following figures will show, the output of shipping from the Scottish yards during January compares quite favourably with that of the same month in pre-war years, a total of 20 vessels, with a gross tonnage of 20,220 tons being launched. The details are shown in this table :—

	Clyde.	Forth.	Tay.	Dee and Moray Firth.
Vessels ...	10	5	1	4
Tonnage ...	15,117	2,236	1,900	967

All the yards are well booked up with orders and, provided that the labour trouble can be satisfactorily overcome, there would seem to be no other hindrance to a period of much prosperity. The need for new shipping is very great.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—What is regarded as the greatest congestion of tonnage ever experienced at the Bute Docks has taken place this week, and the difficulty of handling so huge a quantity of tonnage has been very great. If shipments are comparatively low, it is because of the inefficient conditions of the tipping facilities, and apparently there appears no prospect of an improvement for some considerable time. It is now estimated that it would take at least six months to bring the docks into their pre-war condition of efficiency, and that a heavy expenditure will be entailed to secure this end. Very few stoppages are reported through want of trucks, but disputes are rife and affect production particularly in the western district. Large coals are firm, and the better classes of smalls are also a steady market, but the lower grades of small coals are weak. The embargo on coke shipments is maintained, and it is assumed that the inland need for coking coals is the reason for the action of the authorities. At any rate, its immediate effect has been an easing down in production.

Newport.—Monmouthshire collieries are very well stemmed, and shipments are active. The Alexandra Docks are profiting from the congestion of other ports, and there is every indication that the flow of diverted tonnage will be continued. The collieries are proceeding well, and the only weak spot is the lowest grade small coal.

The Pitwood Supply.—The shortage in the supply of pitwood continues, and fears are entertained that allocations to collieries may have to be reduced. It came, therefore, as a surprise to the market, that despite the shortage the syndicate supplying the Admiralty collieries had decided to invoice all supplies as from this week at 60*s.* per ton ex-ship, as compared with 65*s.* per ton, which had been the ruling price for some time past. A meeting of South Wales importers was immediately convened, but it was decided to take no action in the matter, and it is explained that the step indicated has been taken chiefly on account of the fall of between 4*s.* and 4*s.* 6*d.* per ton in freight, and about 3*s.* 9*d.* per ton in the costs of war risks insurance. Exception, however, is taken to the action of the syndicate by importers generally on the ground that the reduction of the price may injure their competitive power, and drive a larger measure of the import business into the hands of the syndicate. On the other hand, however, it is pointed out that the syndicate confine their supplies to the Admiralty collieries.

Irregular Stoppages at Collieries.—Attention is again directed to the large number of irregular stoppages which take place in the South Wales coalfield. At the meeting of the Coal Board on Monday the owners entered a strong protest against the multiplicity of these stoppages, but on the application of the workmen's chairman, it was agreed to suspend prosecutions until the holding of a special meeting of the Board to deal with the matter.

Wage Costs, Absenteeism and Coal Outputs.—Mr. Finlay A. Gibson, secretary of the Monmouthshire and South Wales Coalowners' Association, on Monday issued two very interesting statements bearing on the miners' demand for an increase of 30 per cent. in wages. One of these discloses the startling fact that while since 1888, the output per annum per person employed above and below ground in the South Wales coalfield has fallen from 299 tons to 224 tons, the wage cost of producing this annual output has increased from 52*l.* to 197*l.* The other statement deals with the evil of absenteeism, and shows that between July, 1917, and January 11, 1919, over 4,500,000 turns were lost by the Welsh miners through avoidable absenteeism from work, and that this voluntary abstention from work involved a loss of over 6,000,000 tons of coal.

TINLESS BEARING METAL.—We read in *The Iron Age* that letters patent have been granted to Mr. W. D. Berry, president of the Berry Metal Company, New Brighton, Pa. for a tinless phosphor-bronze bearing metal. During the war, and while the Government was pleading for everyone to conserve tin, Mr. Berry made experiments, the outcome of which has been the development and perfecting of the tinless bearing metal in question.

THE RÖNTGEN SOCIETY.—The question of "Protection in Diagnostic X-Ray Work" once more came before the Röntgen Society last Tuesday, in connection with a paper read by Dr. med. F. Hernaman-Johnson, who drew attention to the effects of scattered and secondary X rays. In spite of all that had been urged, he remarked, many apparatus were still far from safe, and the opinion was unfortunately still prevalent that hard rays which had penetrated lead glass must be harmless. Such rays, he had found, might still be able to excite fluorescence, though they would hardly cause dermatitis. The operator might be safe when close to a screen, but no longer so further off, because the whole atmosphere of the room was charged with scattered rays, and the couch and the patient to badly diffused rays. With respect to the secondary radiation, the dangers had, perhaps, been exaggerated sometimes; the secondary rays from iron, copper, zinc and lead were harmless, but those from nickel and silver did not seem to be—one hardly sees why nickel should, in this one respect, differ so strongly from iron. Particulars of this one case to which Dr. Johnson referred, were subsequently given by Dr. Metcalfe, who related that a festering burn had developed under his wrist-watch of silver, the burn being finally of the size of the watch, in spite of the lead glove he wore over the hand and the leather strap under the watch. Three weeks later two smaller spots had shown on his legs, due, apparently, to small pieces of nickel in his wear. Various devices for protecting both the patient and the operator, and for preventing scattering of the rays from the couch, were discovered. How little the whole problem is understood was indicated by the question asked by Dr. G. B. Batten, the president of the Society, Why the back of the hand seemed to suffer but not the palm, though the latter was really more exposed as a rule. The "Langmuir Exhaust Pump," which Dr. W. Makower, M.A., of Manchester (lecturing during the war at the Imperial College of Science, S.W.), then exhibited, was of the simple type which we illustrated in Fig. 4 on page 83 of our issue of January 26, 1917. It is a diffusion-condensation pump, in which the stream mercury vapour issuing from a nozzle—the end of a flask in which mercury boils—carries the air down with it, and is itself condensed on to cooled walls of the nozzle jacket. Between the vessel to be evacuated and this condenser a liquid-air trap was inserted to prevent the mercury vapour from streaming over into the vessel to be evacuated. The pump produced an excellent vacuum in a few minutes, being worked in combination with a double-barrel rough pump. Dr. Makower, in explaining the principle of the pump, accentuated the need of amply-wide connections in high-vacuum pumps, referring to Knudsen's investigation of this point, upon which we also dwelt in our article quoted.

NOTICES OF MEETINGS.

THE MINING INSTITUTE OF SCOTLAND.—Saturday, February 8, at 2.30 p.m., in the Heriot Watt College, Chambers-street, Edinburgh :—Mr. John A. Vernon's paper on "The Economy of Briquetting Small Coal" will be discussed. Professor F. W. Hardwick's paper on "The Training of Students in Coal-Mining with Special Reference to the Scheme of the Engineering Training Organisation," will be discussed. Mr. David Penman's paper on "A Digest of the First Report of the Mines Rescue Committee" will be discussed. [Copies of the First Report may be obtained from H.M. Stationery Office, 23, Forth-street, Edinburgh, or by ordering through a bookseller.] Mr. P. A. Mossay's paper on "Cooling of Electric Motors, with Special Reference to Totally-Enclosed Motors" will be discussed. A paper will be read by Mr. James Cooper on "The Electric Head Lamp."

THE MANCHESTER ASSOCIATION OF ENGINEERS.—Saturday evening, February 8, at the Grand Hotel, Aytoun-street. The reading and discussion of a paper on "Principles in Jig and Tool Design," by Mr. G. H. Hey, Bedford, Member. The chair will be taken at 6.30 p.m.

THE CLEVELAND INSTITUTION OF ENGINEERS.—Monday, February 10, at 6.30 p.m., in the Hall of the Cleveland Literary and Philosophical Society, Corporation-road, Middlesbrough. Paper by Mr. N. D. Ridsdale on "Notes in the Determination of Phosphorus in Iron and Steel." Should time permit, a short demonstration will be given after the meeting.

THE ROYAL SOCIETY OF ARTS.—Monday, February 10, at 4.30 p.m., Cantor Lecture : "The Scientific Problems of Electric Wave Telegraphy," By Dr. J. A. Fleming, F.R.S., Professor of Electrical Engineering, University College, London (Lecture I). Wednesday, February 12, at 4.30 p.m., Ordinary Meeting : "The Government and the Organisation of Scientific Research," by Sir Frank Heath, K.C.B., Secretary to the Department of Scientific and Industrial Research. The Most Hon. the Marquess of Crewe, K.G., will preside.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Tuesday, February 11, at 6.15 p.m., in the Lecture Theatre of the Literary and Philosophical Society, Westgate-road, Newcastle-on-Tyne, the following paper will be read and discussed : "The Manufacture and Design of Toothed Gearing," by Mr. Joseph Chilton, M.N.E.C.Inst.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, February 11, at 5.30 p.m. Paper to be further discussed : "Centrifugal Pumps for Dealing with Liquids containing Solid, Fibrous and Erosive Matters," by the Hon. Richard Clere Parsons, M.A., M.Inst.C.E. On the conclusion of this discussion the following papers will be presented for discussion : "The Flow of Water in Pipes and Pressure Tunnels," by Frederick John Mallitt, Assoc.M.Inst.C.E. ; "Discharge of Large Cast-Iron Pipe Lines in Relation to Their Age," by Alfred Atkinson Barnes, Assoc.M.Inst.C.E. And ballot for new Members.

THE ASSOCIATION OF ENGINEERS-IN-CHARGE.—Wednesday, February 12, at 7.30 p.m., at St. Bride's Institute, Bride-lane, Fleet-street, E.C., a paper will be read by Mr. A. W. Wyatt, on "The Psychology of Reconstruction."

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, February 13, at 6 p.m. (light refreshments at 5.30 p.m.), at the Institution of Civil Engineers, Great George-street, Westminster, S.W. "The Functions of the Engineer : His Education and Training," by Brevet Lieutenant-Colonel W. A. J. O'Meara, C.M.G., Member.

THE BIRMINGHAM METALLURGICAL SOCIETY.—Thursday, February 13, at 7 p.m., at the Birmingham Chamber of Commerce, New-street. Paper by Mr. O. F. Hudson, D.Sc., Royal School of Mines, South Kensington : "Copper Alloys of High Tenacity."

THE CERAMIC SOCIETY.—Thursday, February 13, at 3 p.m., a meeting will be held in co-operation with the English China Manufacturers' Association in the Central Schools of Science and Technology, Stoke-on-Trent, when a paper will be read by Dr. J. W. Mellor, entitled "Recent Work on the Bone China Body."

ASSOCIATION OF ENGINEERING AND SHIPBUILDING DRAUGHTSMEN ; NEWCASTLE BRANCH.—Friday, February 14, at 7.30 p.m., in the Connaught Hall, Newcastle-on-Tyne. A lecture will be given by Dr. J. H. Paterson, on "Electric Welding" (illustrated by lantern).

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, February 14, at 5.30 p.m., a discourse will be delivered by Professor Cargill G. Knott, D.Sc., LL.D. The subject will be "Earthquake Waves and the Interior of the Earth." Afternoon Lectures, at 3 p.m. : Tuesday, February 11, Professor J. T. MacGregor Morris, M.I.E.E., M.R.I., on "Study of Electric Arcs and their Applications" (Lecture II) ; Thursday, February 13, Dr. W. Wilson, M.B., C.M., F.R.A.S., on "The Movements of the Sun, Earth and Moon" (Lecture II) ; Saturday, February 15, Professor Hugh Percy Allen, M.A., Mus.Doc., on "Bach's Use of the Orchestra in His Works" some Accompaniments in the Choral Works (Lecture III), with musical illustrations.

THE INSTITUTION OF ELECTRICAL ENGINEERS (SCOTTISH CENTRE).—Tuesday, February 11, at 7.30 p.m., at The Rooms, 207, Bath-street, Glasgow. Paper, "Carbon Brushes : Considered in Relation to the Design and Operation of Electrical Machinery," by Mr. P. Hunter-Brown.

DROP-FORGING PLANT AT VICKERS' RIVER DON WORKS, SHEFFIELD.

(*For Description, see Page* 168.)

Fig. 4. Heat Treatment Furnaces and Oil and Water Quenching Tanks.

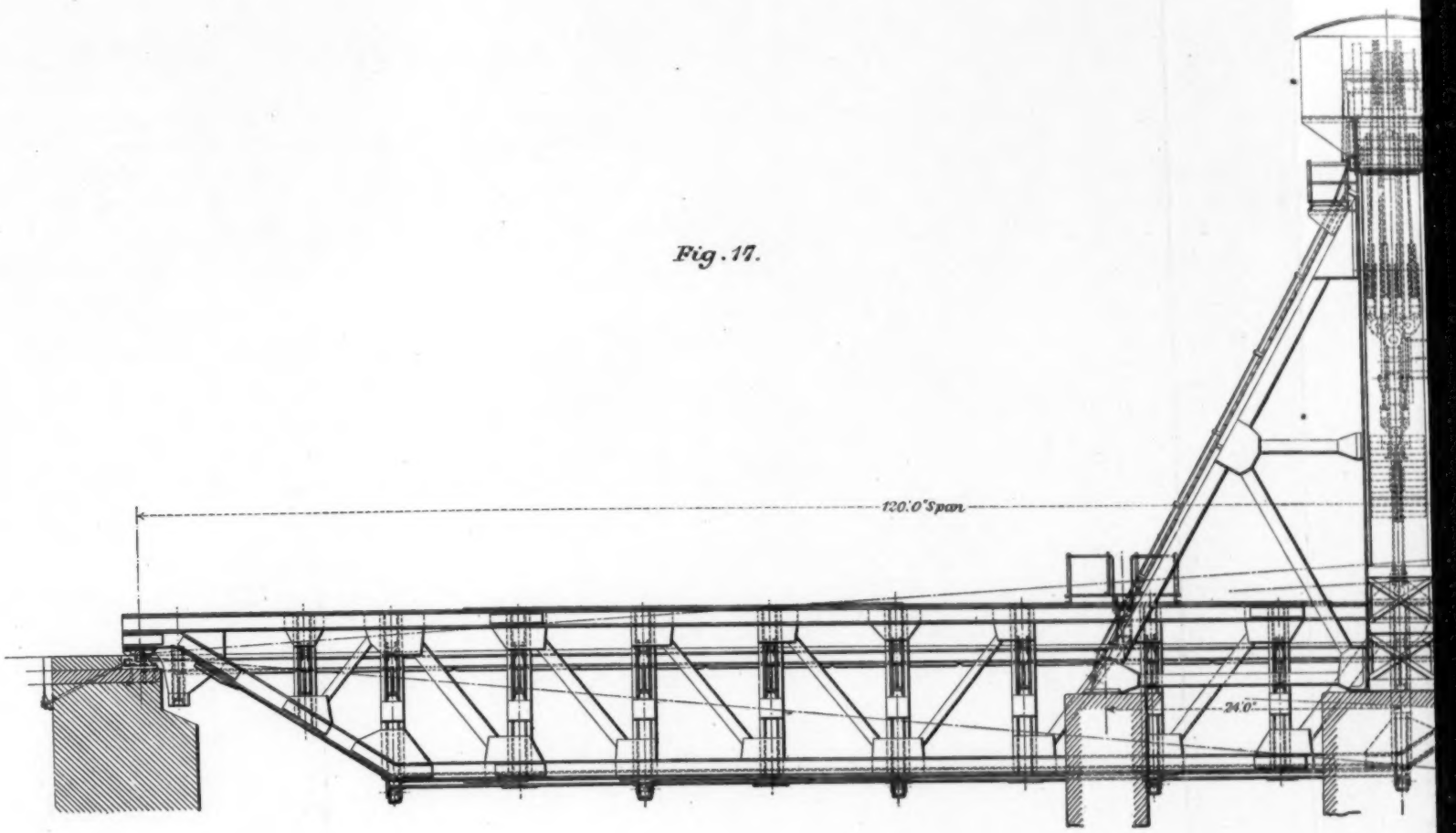
Fig. 5. General View of Main Forging Shop and its Equipment.

THE SOUTHAMPTON TRAIN FERRY; GENERAL ARRA

CONSTRUCTED BY SIR W. G. ARMSTRONG, WHITWORTH AND CO.

(*For Notice, see Page* 186.)

Fig. 17.



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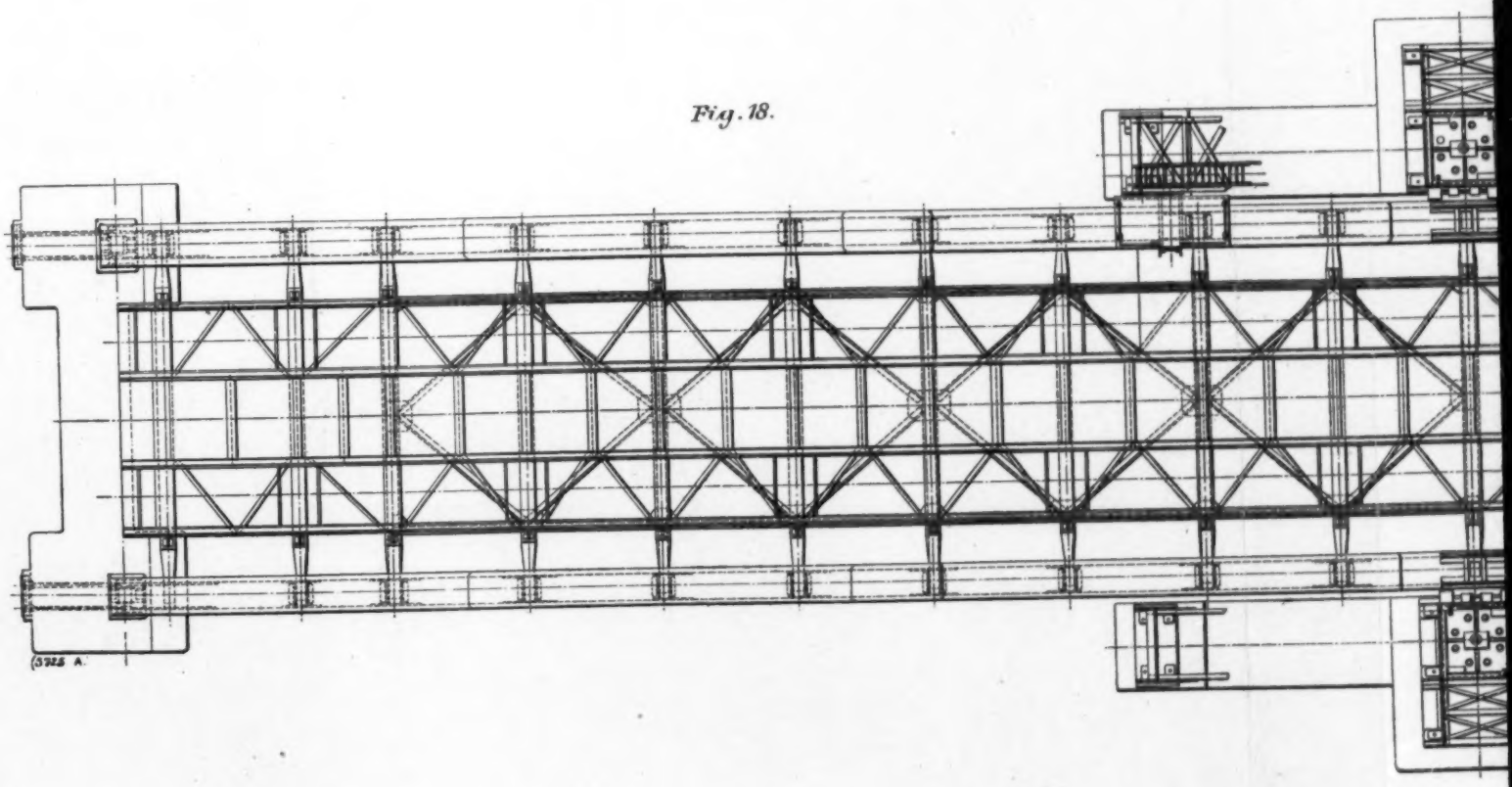

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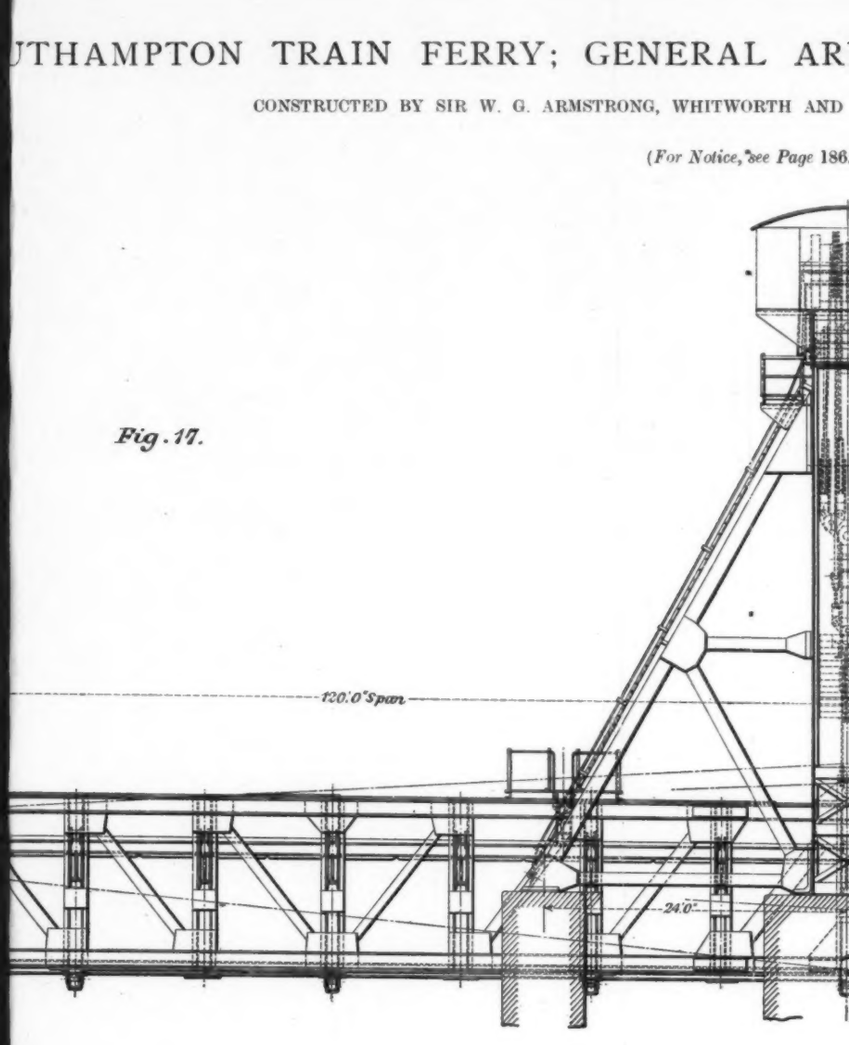

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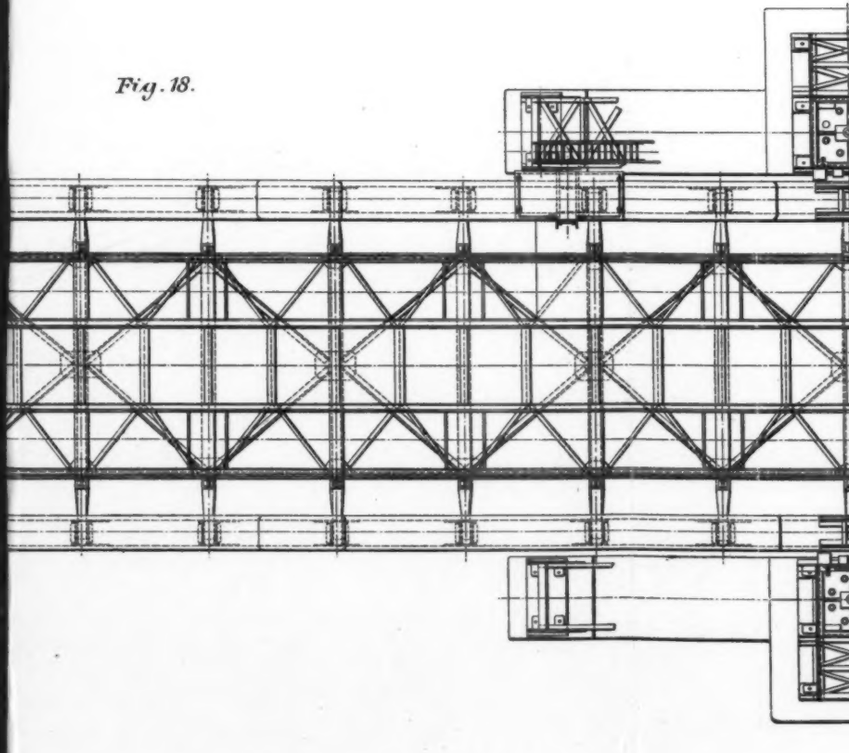

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RTH AND CO., LIMITED, ENGINEERS, NEWCASTLE.

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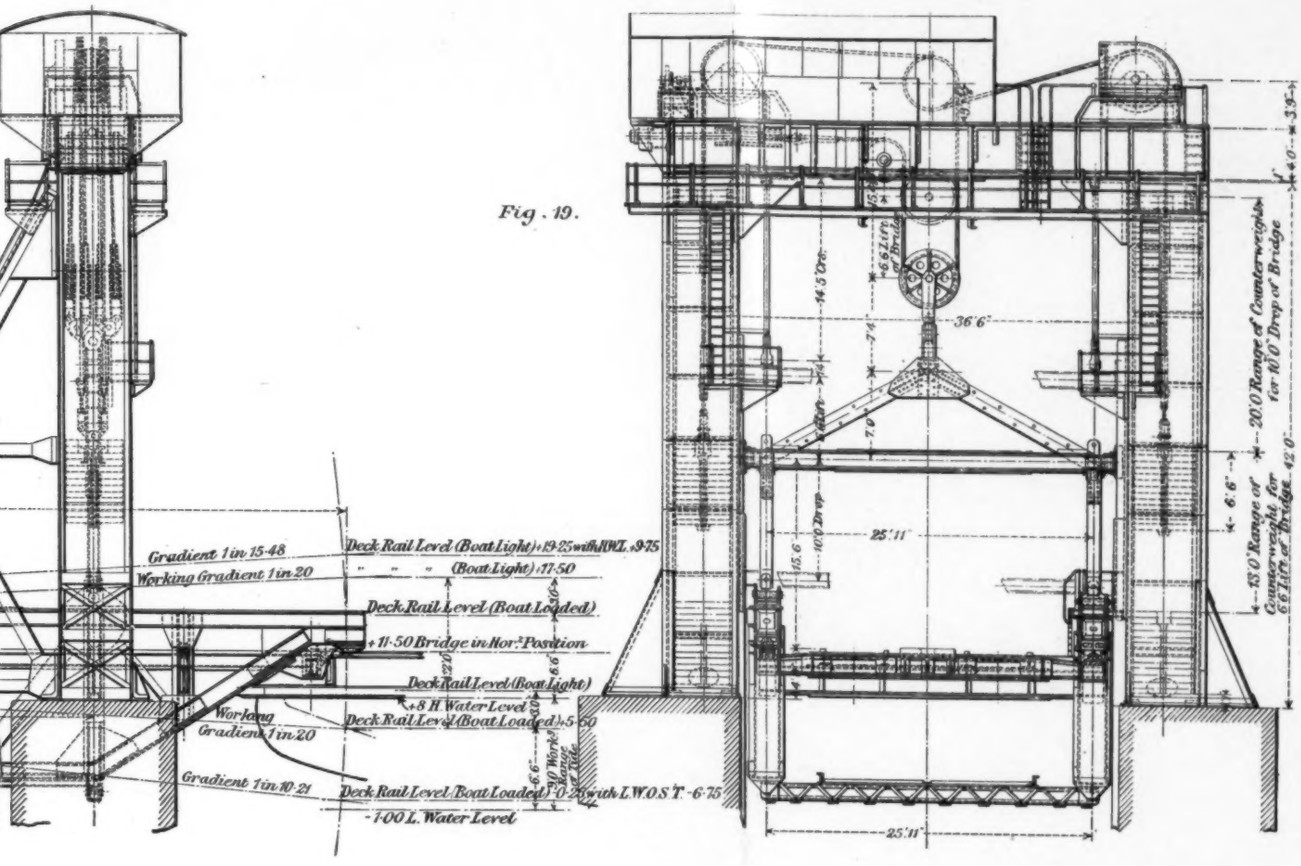

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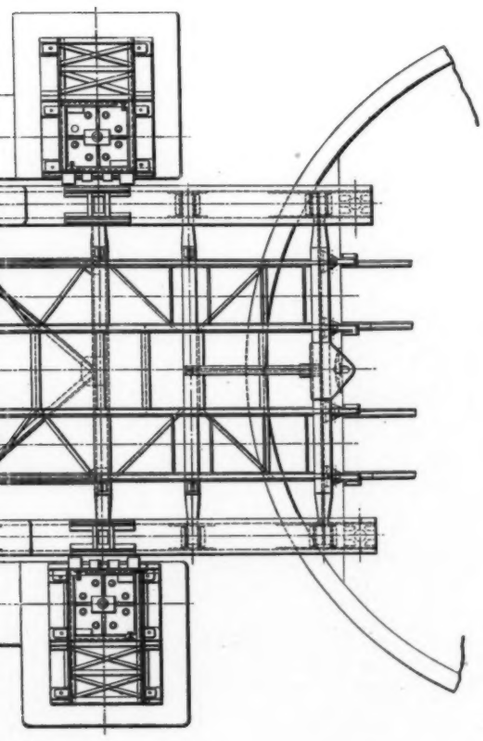

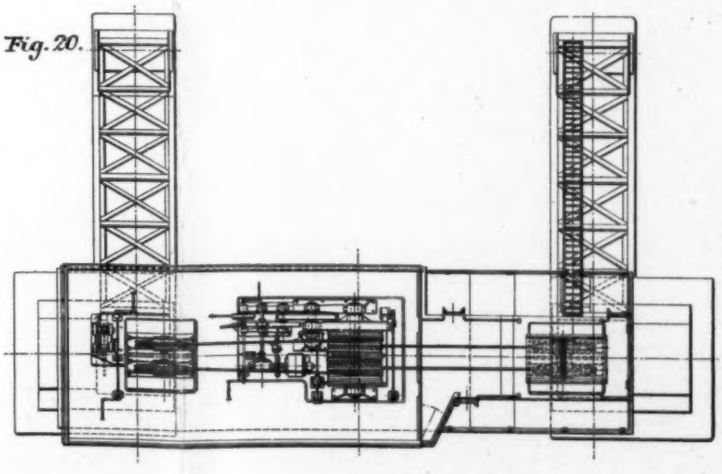

Fig. 20.

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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than Monday morning.

SUBSCRIPTIONS, HOME AND FOREIGN.

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With a Two-Page Plate of the SOUTHAMPTON TRAIN FERRY; GENERAL ARRANGEMENT OF TRAIN FERRY BRIDGE.

NOTICE TO NON-SUBSCRIBERS.

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NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 177.

ENGINEERING.

FRIDAY, FEBRUARY 7, 1919.

INTERNATIONAL LABOUR LEGISLATION AND STANDARDS.

WE have refrained from discussing the present wave of labour unrest which is surging across the country, because we believe that the commonsense of the preponderating majority of the workers will assert itself. Moreover, the strikes which are in progress, and which we hope are collapsing, are not like those with which we, as a technical and industrial journal, are concerned, because they are not due to normal disputes between employer and employed. Evidences have accumulated to show that they are more political than industrial. It is true that there has been a semblance of reason arising from workshop conditions. The shorter hours' agreements, due to a desire on the part of the employers to placate the official representatives of the trade unions, were probably arrived at without due attention being devoted to details, and particularly to the influence which the concession of shorter hours to one class of workers necessarily exercised upon many other classes. It is not necessary, however, even if it were prudent, to deal with those lapses from high statesmanship on the part alike of the representatives of employers and trade unionist organisations. We are disposed to think that the peculiar psychological condition of the country consequent upon the sudden break in the tension due to war and intensive munition manufacture is much more responsible, and that, however elaborate and careful might have been the settlement on the hours question, further demands would still have been made, as they are now being made, by the political propagandists in the labour movement. In fact, the public have recognised the view that the ruling motive of the leaders of the strike is to attack that law and order without which the State as a communism cannot be maintained and without which the recognised authority of trade unionism cannot assert itself.

We have consistently urged employers to adopt as conciliatory a policy as is compatible with the maintenance of British trade in the home and foreign markets, and we have commented, time and again, upon the leniency of the leaders of trade unionism towards recalcitrants within their ranks. For many years they have failed, because sometimes the circumstances were very difficult, to exercise their full power in imposing penalties, and as a direct consequence there has grown steadily and with increasing momentum undiscipline which is largely responsible to-day for the severe trial through which the trade union movement is passing. Trade unionism *per se* is highly commendable and most desirable, because without it collective bargaining, so essential in the relationship between employer and worker, is impossible. We leave the subject with the simple expression of hope that such action as the Government may need to take, will be not in the direction of interfering between the trade union leaders and the recalcitrants, but rather in conserving the rights of the public at large. It will be best for all if the leaders of the trade unions can assert their authority, because thereby will their power for the future be made more firm, more secure, and more lasting.

The situation is not without its reflex on the proceedings in Paris in connection with the League of Nations, and particularly with the aim to establish an international understanding in relation to labour standards and labour legislation. There is reason for the hope that a league of nations may evolve from the present conference, although the main difficulty is one which applies to all questions of international labour legislation. Such a league and a universal labour programme necessarily involve some degree of interference with the right of a nation to manage its own internal affairs. This right has hitherto been held as inalienable. The great war has, however, established once more, and with great insistence, the truth that internal affairs very often overflow in their effects into international relationship, and it has been considered by many of the world's statesmen that the time has come when such interference as may be involved in the scheme aimed at is a lesser evil than the risks due to international differences. If this view is accepted, then it makes the way easier for some attempt to co-ordinate the conditions of industrial welfare. But here again the conditions differ so widely that it will require not only wise judgment and great experience, but the fullest measure of conciliation, to achieve anything like sound standards upon which to base the legislation. It is for this reason important that the present imbroglio in the trade union ranks should be straightened out and that trade unionism should be put upon a definite and sound industrial basis. The problems to be faced in settling these standards, which are a necessary preliminary to co-ordination in legislation, are industrial rather than political. It is to be hoped that trade unionism will throw off the shackles of politics and revert to the old and beneficial procedure of considering industry from the pure economic standpoint. That Mr. G. N. Barnes is, so far as this country is concerned, placed at the head of the movement, will bring not only satisfaction but confidence to all who desire to see the betterment of the working people of this country and of other lands, with standards in industry which will not only tend to higher remuneration and better working conditions, but to a much desired lowering of the cost of living and a raising of the standard of living.

Obviously, the first procedure must be to co-ordinate all factory legislation, and indeed all enactments affecting employment. It would be presumptuous to say that the Factory Acts of this country are ideal, but it will be accepted that we led the way in this direction. There is undoubtedly room for improvement, but first there is need for comprehensive consolidation of these Acts, as by these means the line of advance would be made much more easily discernible. A committee of the Commission on International Legislation, referred to on page 192 of this issue, should certainly tackle the question, and attempt such movement on corresponding, if not exactly similar, lines to that adopted in this country. There are, too, many Home Office regulations, the Workmen's Compensation Act, national insurance, unemployment and other schemes, which ought to be considered and extended in other countries. All these projects in Britain have necessarily added to the cost of production, but we must not be taken as suggesting that there are not compensating advantages. On the contrary, we believe that slum factories are as bad as slum dwellings, and that the bright, well-regulated, well-ventilated, and well-managed factory, with contented workers, will, provided those workers are willing, compensate by increased output for all that has been done in the direction of improving the workshop atmosphere—physical, mental and moral.

The conditions of housing, education and other similar matters which influence the standard of living are much more difficult to unify in the different countries. The conditions in Japan necessarily differ greatly from those in Britain. Indeed, those in the South of England differ from those in Scotland, because of the climatic conditions and of tradition. Yet until the standard of living has been made fairly equal, the standard wage necessary to maintain it cannot well be fixed. Moreover, the purchasing value of the wage, which is the true measure of its worth whatever the monetary system and whatever the coinage, is a problem of great difficulty. All three are related, and must be considered together. But beyond all is the standard of production per unit of wage; there are many incidents in the determining of this factor. The primary one may be said to be climatic conditio s,

which not only influence the virility of the people, but the degree of fatigue due to effort. This is primitive, but in advanced civilisation is still operative. The second difficulty is largely educational, both in the development of initiative, mental and manual, and in the recognition of fundamental laws which are immutable in their results in connection with economics. A third is the degree of mechanism introduced to supplement if not to displace physical effort, and it will be recognised that by this means the first and second difficulties may be overcome, because fatigue is largely dependent upon the degree of manual effort, while education is stimulated by the evidence of the fruits of ingenuity. We say nothing about the necessity for capital to increase mechanism since that is not quite the point at issue. The final difficulty is the degree of willingness to overcome primitive disabilities and to utilise to the highest conceivable extent the mechanism provided. In fixing the standard of remuneration it becomes necessary to fix the standard of output per unit of wage. There is no doubt that in America earnings are higher than in this country and hours are certainly not longer. In Germany the hours were longer than in this country, the mechanism available is as good if not better, and consequently the production per unit is as great if not more. Which of the countries is to be accepted as pointing the way to a standard of wage per hour? If America, then our standard of output must be greatly increased, because only by this means can we hope to retain our place as a great exporting nation, and only by exports can we hope to purchase the raw materials and the proportion of food not produced in this country, but necessary to maintain existence. These are some of the salient points which must be considered in attempting equality for the working classes in all countries.

We commend the aim, but even this cursory consideration of the problems suggests the difficulties. Whether wise counsel, experience and judgment will enable these difficulties to be overcome time will tell, but in any case the mere fact that the condition of the workers in all countries is to be considered by an international commission of statesmen, and that there will be comparisons of those conditions, must be for the good of this country. It will be recognised, we think, that so far as desire to better the condition of the people is concerned we hold a high place. Our workers are highly skilled and ingenious, our employers are enterprising and sympathetic and capable of improving all the mechanical contributories to production. All, therefore, that is needed is a broader basis of negotiation and mutually sympathetic understanding to ensure a higher degree of production per unit of time, which after all is the most essential condition to the prosperity of a great industrial nation.

MOVEMENTS OF SMALL PARTICLES WITH AND AGAINST LIGHT RAYS.

When in the first years of this century Lebedew in Moscow,* and Nichols and Hull† in New Hampshire finally succeeded in establishing that light really pushes back a surface on which it falls, as had long been predicted on the various theories of light accepted at different periods, old suggestions as to the cosmic importance of this mechanical radiation pressure were revived. Bredichin took up an old suggestion of Kepler's, of 1619, ascribing the light of the tails of comets to the corpuscles according to the emission theory. Svante Arrhenius pointed out that the radiation pressure acting on fine dust particles, rather than on coarse particles, would drive the fine dust away from the sun and stars and thus give rise to the solar corona, to aurorae and to cosmic nebulæ. Schwarzschild, later Poynting,‡ who also demonstrated the tangential component of the light pressure and its recoil against the source of light, and J. W. Nicholson§ investigated the energy relations in these phenomena. But, so far as we are aware, no one seriously attempted to demonstrate the actual repulsion of dust by light. Yet a confirmation of the original experiments would have been desirable; for the verification left room for doubt. The real light pressure may be obscured by various other effects, for instance, by the radiometer effect which had first been mistaken for it, and while Lebedew succeeded best when suspending his apparatus in a high vacuum, Nichols and Hull obtained the best results at gas pressures of 16 mm. of mercury. When, last year, Professor F. Ehrenhaft, of Vienna, first experimentally attacked the dust problem by letting the light beam fall on very small spherules of different substances, metals, metalloids, smoke, vapours, he found not only that some substances drifted with the light, but also that other spherules moved as distinctly against the light. The former fact is only another verification of the radiation pressure; the latter fact seems to contradict all theory. There may be some flaw in Ehrenhaft's experiments; but the main facts seem to be established, and his researches only strengthen the impression that there may be some unknown, obscure factor at work in these novel experiments, as probably in those of Lebedew and of Nichols and Hull. In any case the new experiments are exceedingly curious and in their essential features relatively simple.

Before describing Ehrenhaft's new investigations we should perhaps mention that he has for years been experimenting with the smallest particles of solids and liquids producible by various means, and that he has arrived at the conclusion that the electronic charge is not the ultimate unit of electricity; he considers that mercury particles floating in atmospheres of nitrogen or carbon dioxide may carry charges of half an electron or a quarter of that unit, and further—a point important for the experiments we are going to notice—that mercury particles may be exposed for many minutes to the filtered rays of the arc beam without undergoing a diminution in size. In these conclusions he is not in accord with Millikan and other scientists. But he is certainly one of the few experts in the domain of experiments on small particles and their rates of fall in gravitational and electric fields. The novel experiments, to the description of which we proceed, are of this kind; they were published under the title "Photophorese" in the *Annalen der Physik*, of July 12, 1918, pages 81 to 132, and the few diagrams we give on the next page are reproduced from that journal.

The main parts of the apparatus are the following. The beam of an arc lamp is sent through a tubular stop, lenses and a heat filter (10 cm. of water) into a cylindrical observation chamber, hermetically sealed, in which the double cone of light (the vertex of which is in the focal plane) can be observed by a microscope adjustable in various directions; the cone itself can be adjusted in the directions of its three vertical co-ordinates. Beyond the chamber and the microscope the parts are exactly repeated in the opposite order. On both sides of the chamber sector shutters are further interposed. Thus, either the beam coming from the left side, or the beam from the right side may be studied, or both the beams may be simultaneously visible, co-axially and coinciding or parallel to one another in horizontal or vertical planes. The cylindrical chamber is connected with an air pump, and there is an inlet for the gas and the particles to be observed and an outlet for them. The top and bottom of the chamber form the disc electrodes of an electric condenser. The particles introduced into the chamber slowly fall through the light cone under the action of gravity and may, by charging the condenser, be stopped in that fall by the electrostatic field when they are themselves electrically charged. The double cone of light should have the shape of an X; as seen with the microscope it looked like the section of a bi-concave lens, and it appears so in the diagrams, Figs. 1 to 5; the rest of the field is faintly illuminated. In the most intense part of the beam the energy density was, during the experiments, 327 times that of the unconcentrated sun rays on the earth's surface. As the light passed through glass and 10 cm. of water it was deprived of its ultra-violet and infra-red rays, and the wavelengths of the light ranged between 4 and 12 × 10^{-5} cm. The particles experimented with were roughly of the same order, being spherules from 20 × 10^{-5} to 3 × 10^{-4} cm. in radius. There might be only a few dozens of these spherules in the field; sometimes they were crowded. As seen, the sulphur particles, *e.g.*, would appear as mere dots or as distinct spherules, which, by the way, when left to themselves for hours, would coalesce to form well-defined crystals. A scale was visible in the field of view, and the observer watched the period it took an individual particle to cross its divisions.

The particles were produced in various ways, by evaporating metals, sulphur, iodine; by combustion (cigarette smoke); by kathode volatilisation in indifferent gases (hydrogen, nitrogen, argon); by passing these gases through liquids so as to raise a mist, etc. In most cases the particles were suspended in the indifferent gas and entered the observation chamber on opening a tap. The mode of introduction is not especially explained in the article, which is regrettable; any stream motion would, of course, have to be avoided. We assume that the evacuated chamber was first filled with the respective gas, and a little of the dust-mixture admitted when all motion had ceased. In the first series of experiments the gases were at atmospheric pressure and neither the particles, nor the condenser were charged electrically. Fig. 1 exemplifies a typical observation. The light beam enters the chamber—which is not in any electrostatic field, as just stated—from the left; a little spherule of silver flows in from the top and descends under the action of gravity very slowly in the dark portion of the microscopic field. As soon as it enters the light cone, it is deflected and carried away almost horizontally in the direction of the light rays; having left the beam, it descends again vertically. Such a particle is called light-positive, because it moves with the light; silver, gold, mercury, cadmium (all suspended in nitrogen), turpentine soot and camphor vapour in air are of this type; potassium and, to a weaker degree, sodium and magnesium, are likewise light-positive.

The experiments looks like a surprisingly simple and clear verification of the mechanical pressure of light. But the experiment is next tried with sulphur spherules in argon or nitrogen. Again the particle is deflected as soon as it enters the intense beam (Fig. 2), but this time it travels against the direction of the incident rays. This altogether strange behaviour of light-negative sulphur is shown by selenium, tellurium, bismuth, thallium, arsenic, phosphorus, iodine, nitrous acid vapours, smoke from cigarettes and wood; lead is also faintly light-negative. That there was nothing peculiar about the left-hand side of the apparatus is shown by Fig. 3, in which the upper light rays enter from the left, the lower from the right; the selenium particle first moves to the left, descends a little in the space between the two cones, and then moves to the right, in both cases against the direction of the incident rays. Since there are light-positive and light-negative particles, one looks for light-neutral particles; one of these substances is the water vapour carried by both the oxygen and the hydrogen when water is electrolytically decomposed. When different particles are mixed, some travel with the light, some against it; Fig. 4 exemplifies experiments made with mixtures of silver and sulphur, or of gold and smoke. The light thus sifts mixed particles. It does this also with particles of the same substance, differing in size or in other respects. Sometimes it is seen that one particle overtakes another of the same substance, but there may even be a change in direction. Selenium, evaporated in pure argon, is usually strongly light-negative, as mentioned. When the evaporation is performed at high temperatures, however, red particles are obtained which are intensely light-positive. Such changes are likewise observed with tellurium, arsenic and antimony when volatilised in nitrogen or hydrogen in small quartz tubes.

All these particles were electrically neutral; evaporation does not in itself give rise to ionisation. When the particles were electrically charged, however, the phenomena and the velocities remained unchanged. Thus the notion seems to be disproved that small frictional electric charges might be responsible in some way, though one does not quite

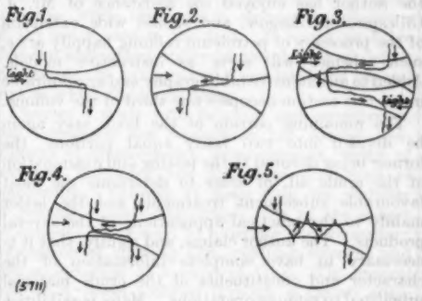
* See Engineering, December 27, 1901, page 874.
† See Engineering, May 19, 1905, page 645.
‡ See Engineering, May 18, 1906, page 659, and September 1, 1909, page 342.
§ See Engineering, September 30, 1910, page 453.

understand how. In the next series of experiments the condenser was excited, and the particles were electrically charged, the electrostatic field tending to drive them upward. The current was turned on (Fig. 5) after the particle (light-positive) had nearly completed its descent; the electric repulsion lifted the particle again, whilst the light deflected it; the current was again interrupted, the particle sank, and was once more raised by closing the circuit. Thus the W curve of Fig. 5 was obtained; with a light-negative particle the curve was reversed. By adjusting the field, Ehrenhaft then suspended a particle half way down the cone, and admitted the left-side beam; the particle travelled to the right (or left); he then shut the left arc off and turned the right arc on; the particles now travelled to the left (right); and in this way he could keep a particle moving to and fro. Similar reciprocating movements were obtained with strongly photophoretic substances, without exciting the electrostatic field, by reversing the direction of the light incidence while the particle was still in the light cone. The experiments were further varied by experimenting with monochromatic rays from different parts of the spectrum; the phenomena were feeble since the light intensity was feeble, but still of the same nature.

So far the experiments had been made at atmospheric pressure or at steady pressure. The gas pressure was then reduced in steps, down to 14 mm. of mercury—not a high vacuum, of course. Qualitatively the phenomena did not change, *i.e.*, light-positive substances remained so, and light-negative ones also. But the actual velocities of the particles in the light increased as the gas pressure was more and more reduced. It was also observed that particles travelled at a higher rate in hydrogen than in nitrogen and argon, as one would expect from the diminished friction in the less dense gases. In the quantitative determinations it was found that a silver particle, *e.g.*, crossed successive scale divisions of $11{\cdot}8 \times 10^{-5}$ cm. each in intervals of 0·67, 0·62, 0·66, 1·17, 1.70 second, travelling quickest in the most intense part of the beam; on reversing the direction of the light rays the movements took 3·0, 1·6, 2·1 seconds, the particle having meanwhile drifted into a region of weak light intensity. An influence of the size of the particles has already been pointed out. It was observed that, within the size limits above stated, the smallest particles travelled at the rate of 2×10^{-5} cm. per second, that medium-sized spherieles attained the maximum rate of 18×10^{-5} c.m., and that the velocity foll off again for larger particles. Such an effect of size was quite in accord with previous calculations.

If all thermal or secondary forces (convection currents, radiometer effects, etc.) were excluded, a particle on which light falls should be subject only to gravity, to Brownian movements, to electrostatic forces and to the radiation pressure which we had better call the photophoretic force, since it may be both positive and negative. In the absence of any electric force the velocity of the observed movement v_l due to the photophoretic force p_l should be $v_l = p_l \cdot B$, where B indicates the mobility of the particle which depends upon the friction of the particle in the gaseous medium and changes with the size and shape of the particle and the density of the gas. This dependence of B, Ehrenhaft states—the argument is difficult to understand—becomes appreciable only at gas pressures at which the mean free path of the molecules is comparable to the radius of the particles. The influence of friction on the movement of bodies through gases is best known for spheres, and Ehrenhaft's experimental particles were spheres of the order of magnitude, at atmospheric pressure, of the mean free path and were too small to be affected by any appreciable temperature difference between the side exposed to the light and the other side. The mobility of B is known from the velocity of free fall (law of Stokes-Cunningham) and from the Brownian movements. The determinations were confirmed by the observations of the diffraction colours of the falling particles; slowly-falling silver particles, *e.g.*, appeared yellowish-green, and as the size and velocity of falling increased the colour changed to yellow and orange. The energy-density determinations made further confirmed the other measurements. For this purpose the condenser chamber was transformed into a calorimeter; the temperature rise observed on the beam was 0·06 deg. C per minute. According to Schwarzschild the ratio of the light pressure to the incident light energy should, with light of the mean wavelength of 7×10^{-5} cm., (the mean wavelength of Ehrenhaft's experiments) be a maximum for spherules of $9{\cdot}8 \times 10^{-6}$ cm. radius, perfect reflection of the light to the sphericles presumed. Debye later extended these calculations to imperfect reflectors, and Ehrenhaft's observations agree with these calculations. The maximum force observed was $p_l = 323 \times 10^{-12}$ dyne. Any buoying up of the small sphericles experimented with by ascending gas currents or any drift owing to temperature differences between gas and spherule would, it is asserted, be inappreciable according to the researches of G. Jäger and D. Konstantinowsky.

In this respect and in several others, Ehrenhaft considers experiments made with spherules floating in gas preferable to the arrangements used by the original demonstrators of the radiation pressure. Lebedew let the light fall upon the wings (0·5 cm.



radius) of a torsion balance suspended in a vacuum of 0·0001mm. of mercury. That is a high vacuum; yet a cubic centimetre of a gas at that rarefaction still contains some 4×10^{12} molecules, and the mean free path of the molecules would be something like 70 cm., Ehrenhaft points out. Nichols and Hull succeeded best with gas pressures of 16 mm., and 0·01 mm. of mercury; their suspended discs (1·28 cm. diameter), were large compared with the mean free path (5×10^{-4} cm), and as it is very difficult to suspend a disc system perfectly vertical, any ascending gas current might (and did) give rise to apparent attractions as well as to repulsions. Ehrenhaft was not troubled with these difficulties. In his special experiments concerning the influence of reducing the gas pressure on the movements of his particles, he observed that the velocity v_l increased rapidly as the gas pressure decreased, and that the rate $p_l = v_l / B$. proved constant. That is to say, the photophoretic force depends only upon the intensity of the radiation and the physical condition of the spherules, but not upon the gas pressure, except in so far as this pressure affects its mobility. This constancy was demonstrated both for the light-positive silver in nitrogen as for the light-negative sulphur in argon. The light-positive movement (apparent repulsion by light) or radiation pressure of small sphericles of some substances is in accordance with the various theories of light (emission, undulatory and electromagnetic) and with predictions. The opposite light-negative movement of other substances and the light-passivity of others again (about which Ehrenhaft says very little) are novel, strange facts not fitting into any theory apparently. One may fancy that the possibility of frictional electrification and of thermal influence was not altogether excluded. It looks suggestive that all the metalloids and metal chemically related to sulphur were light-negative. One would require a very detailed description of the construction of the observation-chamber, however, to justify any speculations of this kind, and Ehrenhaft does not give such a description. It will be advisable, therefore, to wait for a continuation of these experiments, in which Ehrenhaft is engaged together with Gerda Laski and J. Paranikiewicz, and for the confirmation of their results. Meanwhile we agree with Ehrenhaft that the relations between matter and radiation may be very complex and not altogether explicable by the simple mechanical radiation pressure.

NOTES.

The Drying of Fruit and Vegetables.

The war has given a new stimulus to the drying of fruit and vegetables in Switzerland, and the plentiful fruit crop of 1917 caused a revival of many small, domestic and industrial installations which had fallen into disuse. Not all of these were designed and operated on efficient lines, of course. The authorities and the Fruit Department of the Swiss Experimental Station at Wädenswil hence requested Mr. E. Höhn, engineer to the Swiss Association of Steam-boiler Proprietors, to collect information and to draw up a pamphlet for the guidance of fruit driers. This pamphlet of 120 pages (published by the firm of Emil Wirz, of Aarau) contains information that might be appreciated over here, and also gives useful hints as to the treatment of fruit and vegetables before their delivery to the driers and preservers. All vegetables and fruit should be stored dry; green beans, *e.g.*, spoil rapidly when kept wet, and herbs, parsley, leek, &c., can hardly be stored except in dry sand. Fruit may be piled on the dry earth under a roof; it is advisable, however, to provide wooden frames which have ventilating shafts about a metre apart for the fruit piles of about the same height. Such stacking is preferable to the storing of fruit in damp and warm cellars. To place the fruit on hay, straw or paper, either on the floor or in baskets, favours rotting; wooden bins should be disinfected with lime before re-use, and rotten wood carefully be avoided. Potatoes, &c., can be cleaned and peeled in cylinders lined with carborundum and flushed with water. The drying should be effected at temperatures between 60 deg. and 80 deg. C.; only residue (for cattle food) requires drying at 120 deg. and higher temperatures; the drying will take from 8 hours to 20 hours and more. As a rule the trays should not be charged to depths of more than a few inches, and good ventilation should be provided, either simply an upward current, or a circulation by means of fans. Care has, however, to be taken that the cooling vapours do not come in contact with cold material, lest condensation take place. The counter-current principle has not answered for this reason. The preheating of the air should not be too great, and in ovens or kilns with superposed shelves there should be several inlets for the heat. Sawdust may be used as fuel, the hot gases directly playing over the wares; the wood-smoke taste is not objectionable. Coke is the most usual fuel, coal is inapplicable. Drying in boiler-houses is quite feasible, provided proper arrangements for cleanliness be made. Neither wooden trays nor wire trays are free of objections, but there is nothing better available as a rule; the wood rots, and the wires rust and get too hot. Good results have been obtained with single flat trays with perforated bottoms through which the hot gases are admitted. Drying by steam of not more than 2 atmospheres is recommendable; hot oil circulation requires careful supervision, lest the oil be decomposed and high pressures develop. Electric heaters have answered at Aarau; on the average 1·5 kw.-hours are required for drying 1 kg. of green fruit, but that figure has to be multiplied by 4 and higher factors when the estimate is to be based on the weight of dry fruit; generally electricity is too expensive. The book illustrates a large number of ovens, and the appendix on theoretical questions contains useful tables and curves on the dew-point, heat and moisture contents and pressure of air at different temperatures, and waste-heat utilisation.

Electrical Dust Precipitation in the Sulphuric Acid Industry.

In the sulphuric acid industry electrical precipitation of dust and fumes is successfully being used at two stages, firstly in order to clean the roasted gases, and secondly to remove the acid mists from the vapours leaving the acid towers and concentration houses. Some particulars of actual installations are given by A. A. Heimrod and H. D. Egbert, of the Research Corporation of New

York, which put up the installations in question (*Chemical and Metallurgical Engineering* of September 15, 1918). The removal of the dust from the SO_3 gases is necessary because the metallic and mineral particles would poison the catalysts in the contact process and would enter the acid in the chamber process. When the gases from burning sulphur, or roasted pyrites, zinc blende, &c., cannot be cooled but must be cleaned at 1,100 deg. F. and higher temperatures, precipitators of the "plate type" for horizontal flow are used. In one plant 40 tons or 45 tons of pyrites are roasted per 24 hours in two seven-hearth Herreshoff furnaces, and up to 1,200 lb. of dust (chiefly Fe_2O_3) are collected per day by the precipitator which deals with 17,000 cub. ft. of gas containing 8 per cent. of SO_3 at 1,100 deg. (and even 1,400 deg. F.) per minute. The gases pass through two parallel precipitator sections, each provided with dampers at the inlet and outlet; as a rule only one section is worked at the time. The collecting electrodes as well as the precipitator electrodes are steel plates stiffened with ribs and suspended in brick chambers by T-members from cast-iron frames and insulators; the insulators are above the chambers and consist of corrugated porcelain hoods. Where the rods pass through the chamber ceiling, the insulation is effected by the aid of pyrex glass bowls or oil lutes; further particulars about these important features are not given. The walls of the chamber consist of firebricks (inside), insulating bricks, and ordinary bricks (outside); below, the chambers taper down in hopper fashion, and the whole plant is raised on columns so that the dust may be easily emptied from the hoppers. Transformers for currents of 50,000 volts, directly joined to the power line, and a 2-h.p. three-phase synchronous motor, also operated from the line, constitute the electric equipment, together with the switchboard. In the contact process, where the gases are cooled down to 600 deg. F., and in concentration plants, where vapours often at only 200 deg. F. have to be dealt with, the precipitators are of the "tube type" for vertical flow. In a recent plant in Wisconsin 17,500 cub. ft. of gases from blende roasting furnaces are treated per minute in two units, each of 36 pipes, and 7,600 lb. of dust (with 22 per cent. of zinc, 2·2 per cent. of lead, 30 per cent. each of iron and of sulphur) are collected per 24 hours. The pipes are 15 ft. high, 12 in. internal diameter, and are made of steel; the discharge electrodes are jack-chains axially suspended in the tubes; the bottom chamber is made of concrete, and the whole precipitator occupies a space of 17 ft. by 28 ft., 35 ft. high; the chains are shaken by hand levers; the precipitator is worked by currents of 85,000 volts and requires 18 kw. To precipitate the acid fumes, the tubes, 12 in. diameter, are built up of sectional tiles joined by acid cement; the axial iron wires are encased in a thick star-shaped lead casting and are mounted in lead. In one plant yielding 50 tons of acid of 66 deg. Baumé per 24 hours, 3,000 cub. ft. of gas have to be treated per minute; there are 16 collecting pipes. Another plant deals with 30,000 cub. ft. of vapour per minute, and 25 tons of acid (40 deg. Baumé) are gained per day in four precipitator units, the tubes being of lead in this case. The electric power consumption is always said to be low.

Standardisation in Japan.—We read in *The London and China Telegraph* that a report has been issued by the Japanese Government on the work of the committee which has been conducting an investigation into the standardisation of freight ships. It is claimed that the adoption of standards in the building of freighters will facilitate the supply of materials and enhance the efficiency of the yards, and will also reduce considerably the cost of ships.

Iron and Steel Prices.—Notices Nos. 28, 29 and 30, issued by the Minister of Munitions, dated January 24, 27 and 30, deal with new maximum prices for tin plates and terne plates, for steel plates, sheets and black plates, and for steel slabs, &c. The Minister of Munitions has also announced that, following on the withdrawal on January 31 of the certain subsidies on steel, the drawbacks payable to the Government in respect of exports of steel have been reduced as from February 1. Particulars of the reduced rates of drawbacks may be obtained on application to the Ministry of Munitions, Steel Department (Room 104), Hotel Victoria, W.C. 2.

LITERATURE.

Petroleum Refining. By Andrew Campbell, Member of Institute of Petroleum Technologists. With a foreword by Sir Boverton Redwood, Bart. London: Charles Griffin and Co., Limited, 1918. [Price 25s. net.]

Concurrently with the vigorous search that is being made for the discovery of subterranean-stores of petroleum in this country and the announcement of the sinking of the first trial well, comes Mr. Campbell's treatise, describing the construction of works for refining the crude product, and the nature and purpose of the processes involved. The book is eminently practical, as might be expected from one who by long experience has enjoyed "unique opportunities of acquiring the fullest information in regard to the principles and practice of petroleum refining." Throughout may be noted the close attention to detail that comes from intimate connection with the actual operations of refining, and not the least valuable portion of the work are the specifications for constructing the plant required, with the diagrams accompanying the forms of contract. In preparing this section the author has enjoyed the assistance of Mr. J. Gillespie, of Glasgow, and should wide extension of the processes of petroleum refining happily arise, such schemes will serve as instructive models. Added to an extensive bibliography and an admirable index this section occupies one-third of the volume.

The remaining portion of the book may again be divided into two fairly equal portions, the former being devoted to the testing and examination of the crude oil, in order to determine the most favourable subsequent treatment, and the latter mainly to the practical applications of the several products. The author claims, and rightly, that it is necessary to have complete information of the character and constituents of the crude material submitted to refining operations. Many possibilities have to be considered depending on the exigencies of local markets. If the plant is on a sufficiently large scale and adequate transport facilities have been secured, the market for products is world-wide, and the refiner can profitably dispose of his proceeds. But in catering for smaller markets and special demands the crude oil most be treated in such a manner as to give the most profitable return. For example, there may be a good local market for fuel oil, and from a financial point of view it may be desirable simply to remove either the benzine or the kerosene fractions, leaving the residues available for fuel. The nature and scope of refining operations ultimately to be embarked upon cannot be most profitably determined without accurate knowledge of the extent of possibilities latent in the crude oil, and consequently Mr. Campbell gives a detailed examination of the analysis usually practised and of the apparatus in use. The diagrams illustrating a full report from a 5-gallon test, and also exhibiting the percentages of products derived from the "flow" of the oil through a complete plant are decidedly practical and instructive.

Starting with the determination of specific gravity, the author next discusses the methods of determining the flash and setting-points. Much of the description of the apparatus usually employed is taken directly from Sir Boverton Redwood's well-known work, and when deviating from the methods recommended by that authority, other instruments and methods are employed, these are described in the words of the original proposer. The estimation of benzine, kerosene and heavy oil fractions is effected by Professor Engler's methods and the Laboratory Book of Mineral Oil Testing is drawn upon for directions in using the Mahler bomb, when determining the amount of sulphur in kerosene and the calorific value. If the lamp method with aspirating apparatus is preferred to that of the bomb method, the author recommends the substitution of glass tubing as an absorber in place of the ordinary glass marbles, as possessing the advantages of ensuring a more thorough scrubbing action and opposing less resistance to the current of gas. For estimating viscosity, we return again to an extract from Sir B. Redwood's work; and to assist nomenclature and analysis of colour a very lengthy description of Lovibond's tintometer is supplied. Pitch testing, involving as it does the estimation of a number of variable factors involving the "flow-point," ductility, penetration, bitumen content, fixed carbon, &c., includes some interesting points that might have been treated more fully with advantage.

Passing over such topics as selection of site for erecting a refinery, the probable existence of facilities of transport, and planning the buildings with the view of securing the greatest economy and convenience, the third and main section of the book is reached wherein are demonstrated the methods by which the objects of distillation are attained on a commercial scale. The objects to keep in view are, a low fuel consumption per ton of crude treated, and the desirability of eliminating any necessity of redistilling once-run fractions. The space devoted to the treatment of so large a subject is a little disappointing. Especially some details might have been given of the processes for separating aromatic hydrocarbons from light petroleum. In these days, when every possible source of toluol for the manufacture of high explosives is being explored, the reader may be disappointed with the simple statement that for this object "the fractionation is more complicated, a number of redistillations being necessary to reach good concentration."

The general process of distillation is simple, and the diagrams are so well selected and detailed as almost to remove the necessity for verbal description. The introduction of preheaters is the application of a well-known principle and scarcely complicates the design. The Trumble still and system of distillation, reproduced from the original description, is of particular interest since the arrangement of evaporators and exchangers demonstrates a convenient and practical form for separating the distillate into several distinct fractions without having recourse to redistillation. How far the process can be extended to heavier parts of crude petroleum does not appear. But as the Shell Company have erected a Trumble retort for the purpose of running asphaltum and carrying on further experiments, hopeful developments are apparently within sight. A good account of Henderson's system is given, but the description of the methods adopted in continual distillation stills is rather slight. The effect and advantages of preheating in petroleum operations are presented with more fullness, due to the reproduction of a paper by Dr. Kraemar, submitted to the Third International Petroleum Congress at Bucharest.

The determination of the amount of solid paraffin present in samples of crude petroleum was explained in the earlier portions dealing with yields of marketable products. Mr. Campbell now handles the subject on a commercial scale. For the extraction of paraffin from heavy oil fractions, refrigerators, utilising either ammonia or carbonic dioxide are in use. For full illustration of the method, Henderson's complete arrangements for treating heavy oil are adequately described, and at a later stage in the process, the same engineer's "sweating stove" comes under favourable review. The final operations which render the sweated wax suitable for candle manufacture consist in decolorising and filtering the material. Several patents are on the market. Scott's extractor and Bryson's filter are selected for illustration and description.

The manufacture of candles to which the separation of paraffin was the introduction is briefly described, but the hand of the expert is recognisable. Many forms of decorative candles are shown as the result of attempts to minister to the æsthetic tastes of a cultivated public, but we are afraid few designs would have received approval from Faraday as being of scientific form. The manufacture of night lights it seems is still continued, though many may have thought that this feeble illumination had not survived the Victorian age.

For some purposes to which oils are applied, it is desirable to render them colourless and inodorous. Chemical treatment is then necessary, but the treatment will vary according to the volatility of the oil and the purpose for which it is to be used. Sulphuric acid is recommended for improving the colour, the object being to precipitate the tar which can be recovered, worked free from acid and used

for fuel. For deodorising both petrol and kerosene fractions, litharge dissolved in caustic soda is the usual agent for removing the objectionable sulphurous compounds. But here, as elsewhere in the scheme of petroleum refining, where enormous quantities of the commodity have to pass through the operation, the interest centres rather in the mechanical operations and the ingenious devices for economic treatment than in the chemical reactions. For the heavy lubricating oils, itself a large industry, the author apologises for his limited experience, which extends to plant of no larger capacity than 100 barrels as washers for petrol and kerosene, but "is inclined to think this a convenient size for working oils likely to emulsify." When liquified sulphur dioxide has to be applied to kerosene to remove the constituents which emit smoke much larger quantities must be handled. The description of Dr. Edeleanu's process, extracted from his pamphlet, "The Edeleanu Process, as Applied to Large Refineries," is informing, both from the chemical and the fiscal side, but the elaborate discussion of costs is of disproportionate length.

The distribution of products, under which heading the author describes the assembling of oil tins, the making of boxes, the cooperage of casks and much extraneous matter has really nothing to do with petroleum refining, but as the object is apparently to supply a complete guide to the industry for the benefit of those who propose to engage in it, such business details acquire some prominence. On this ground it would have been well if the author had seen his way to describe at some length the 'cracking' method of petroleum distillation, the most promising means for deriving the more valuable products from crude petroleum.

Ship Stability and Trim. By PERCY A. HILLHOUSE, B.Sc., M.I.N.A. Portsmouth: Gieves Publishing Company, Limited; London: John Hogg, 13, Paternoster-row. [Price 10s. 6d. net.]

To the ship designer with a real enthusiasm for his work it is always a source of regret that in practically no case does he have the opportunity to study the behaviour of the completed ship, under the service conditions for which she was designed. To the engineer the speed and power trials afford at least an approximation to service conditions so far as the machinery is concerned, but to the ship designer the behaviour of the ship under trial conditions affords no reliable data as to the probable behaviour of the vessel in service. The influence of wind and weather and the varying conditions of lading met with in service are not met with during trials, and it too frequently happens that no further opportunities for observation are available for the ship designer. Any weakness due to defective design or defective workmanship asserts itself and becomes visible on examination, and can thus be dealt with as required; but the behaviour of a vessel in a seaway under all the varying conditions of weather and lading met with in service rarely becomes known beyond the circle of those whose business it is to operate the ship. It follows, therefore, that the behaviour of the vessel at sea is too often ascribed wholly to the design, the influence of the distribution of weights carried in the form of cargo, &c., being largely neglected because it is imperfectly understood. To the older type of ship's officer the seaworthiness of his vessel was almost entirely dependent upon the personal experience and judgment of the stevedore and himself in the disposal of cargo—accurate calculation being unthought of. Within recent times the practice of furnishing technical information in a simple form for the use and guidance of ships' officers has become more general and the shipbuilder has sought to encourage officers to supply notes on the behaviour of their ships under all conditions of service. In this way much useful information may be gained for guidance in the design of future ships, but the usefulness of this information is entirely dependent upon the accuracy with which the essential facts are noted and recorded, and this in turn demands a certain knowledge of the laws governing stability on the part of the observer.

Apart from the good which may accrue to the designer from the accumulation of reliable data, it is in the highest degree desirable that the ship's officers should be in a position to determine with accuracy the condition of their ship with regard to stability at any given time and under any conditions of lading. The idea that this can only be accomplished by the use of intricate mathematical formulæ is unfortunately very prevalent amongst ships' officers, and not the least commendable feature of Mr. Hillhouse's treatise is the success with which he disproves this idea by giving a definite statement of the information required and indicating the manner of its use. While the volume will prove of very great service to ship's officers, both in their studies and in their professional work, it will also be welcomed by students of naval architecture and by many of those engaged upon ship design. Mr. Hillhouse is to be congratulated upon his decision—announced in the preface—to consider the practical rather than the theoretical aspects of the subject, and the result is that the volume deals adequately with practically every problem met with in drawing office practice or necessary for the prompt determination of the stability of a ship under any given conditions. The higher mathematical investigations have been purposely omitted, and as these are rarely, if ever, seen in the ordinary work of the design office, the omission is justified. Nine of the ten chapters into which the volume is divided deal with the various phases of the problems of stability and trim, while the tenth is devoted to definitions of the terms used in the text. It seems probable that the undoubted utility of the chapter of definitions would be enhanced if it preceded the general text in which the terms occur.

Chapter I deals with flotation and equilibrium, and introduces the student to the correct conceptions of displacement, water pressure, centre of pressure, buoyancy and the three conditions of equilibrium. Chapter II deals with the stability of floating bodies—the simple case of the sphere or cylinder being used to illustrate the elementary conception of righting arm, righting moment and the construction of a curve of G. Z. The general case of a vessel inclined through a known angle and involving consideration of the shift of C.B. due to the transference of the wedge of bucyancy, is clearly stated, and illustrated by diagrams, and leads naturally to the well-known expression for G.Z. known as Attwood's formula, and to the equally well-known expression for dynamical stability known as Moseley's formula. The various methods employed in the actual stability calculations are described at length in Chapter III, and these will be found extremely useful by all who have occasion to perform this work. In considering the stability at large angles of inclination no allowance has been made for deck erections, yet the influence of these is in many cases not inconsiderable, and is certainly worth investigation when a complete stability calculation is being undertaken. A table showing the percentage error resulting from the use of different rules in calculating the same area is instructive and interesting. Chapter IV deals with the metacentre—the method of calculating its position and the significance of that position in regard to initial stability. For the benefit of students not too familiar with calculations it would be well if the subsection entitled "Calculation of Height of Metacentre for Ship" were amended so that the final result of the specimen calculation given showed an actual height of metacentre above centre of buoyancy—not moment of inertia of water plane as at present.

Methods of constructing curves of righting arm and righting moment, also curves of dynamical stability, are indicated in Chapter V, while the heeling effect of wind pressure and squalls is dealt with in Chapter VI. To the trained naval architect the effect of free fluid carried in the holds, tanks or bilges of a vessel is well known, and therefore always guarded against, but to the non-technical mind the subject presents considerable difficulty, due to the fact that free surface plays such a prominent part in the effect. Mr. Hillhouse has devoted a chapter, No. VII, to the method of calculating the effect of free water and to the means adopted to minimise the effect of free water surfaces due to the inrush of water following damage to the shell. Chapter VIII details the method employed in calculating the position of the centre of gravity of the vessel, also the well-known "inclining experiment" for the determination of the centre of gravity. This chapter should be of especial use to officers who may desire to make an estimate of the initial stability of their vessels at any time during their stay in dock or just prior to sailing. Chapter IX deals with the question of trim and stability while docking. The effect of adding weights or moving weights already on board, the correction to be made to displacement as read off the displacement scale for excessive trim, and sample estimates of trim in various conditions for an actual vessel form part of this instructive section. A description of Ralston's stability and trim indicator, a mechanical device which obviates a considerable amount of calculation and gives very accurate results, completes the chapter.

Throughout the book there is an atmosphere of the drawing office rather than the lecture room, and to designers, draughtsmen, ships' officers and all those responsible for the loading and handling of ships it should prove of very considerable use. The diagrams are numerous and of excellent quality, and are, along with the text, excellently printed.

BOOKS RECEIVED.

The Post Office London Directory for 1919. In three volumes. Vol. I. *Official, Streets, Law, Court, Parliamentary, Postal, City, Municipal, and Clerical, Conveyance, and Banking Directories.* Vol. II. *Commercial and Trades Directories.* Vol. III. *County Suburb Directory.* London: Kelly's Directory, Limited. [Price for three volumes, 64s.; for Vols. I and II. only, 48s.]

The Fleet Annual and Naval Year Book, 1918. Compiled by LIONEL YEXLEY. London: Chapman and Hall, Limited.

U.S. Bureau of Labour Statistics. Bulletin No. 240. *Comparison of Workmen's Compensation Laws of the United States up to December* 31, 1917. By CARL HOOSLADT, Washington: Government Printing Office. [Price 15 *cents.*]

Technical Handbook of Oils, Fats and Waxes. By PERCIVAL J. FRYER, F.I.C., F.C.S., and FRANK E. WESTON, B.Sc., F.I.C. Vol. II. *Practical and Analytical.* Cambridge: The University Press.

Smithsonian Institution: United States National Museum. Bulletin 102, Part 5. *The Mineral Industries of the United States: Power, its Significance and Needs.* By CHESTER G. GILBERT and JOSEPH E. POGUE. Washington: Government Printing Office.

Cast-Iron in the Light of Recent Research. By WILLIAM HERBERT HATFIELD, D.Met. Second Edition, revised and enlarged. London: Charles Griffin and Co. [Price 12s. 6d. net.]

Warne's Wages Bonus Tables: Showing at a Glance the Bonus at the Various Rates per cent. on Amounts from 3d. *to* 7l. *per Week and also the Total of Wages and Bonus.* London and New York: Frederick Warne. [Price 1s. net.]

An Introduction to Trade Unionism, being a Short Study of the Present Position of Trade Unionism in Great Britain prepared for the Trade Union Survey of the Fabian Research Department. By G. D. H. COLE. Trade Union Series, No. 4. London: George Allen and Unwin, Limited. [Price 5s.]

The Excess Profits Duty and Profits of Controlled Establishments. By ERNEST EVAN SPICER and ERNEST C. PEGLER. Fourth Edition, revised and enlarged. London: H. Foulks Lynch and Co., Limited. 61, Watling-street, E.C. 4. [Price 10s. 6d. net.]

United States Bureau of Foreign and Domestic Commerce. Statistical Abstract of the United States, 1917. Fortieth Number. Washington: Government Printing Office. [Price 40 cents.]

The New Moon: A Romance of Reconstruction. By OLIVER ONIONS. London, New York and Toronto: Hodder and Stoughton. [Price 6s. net.]

A Manual of the Steam Wagon-Maintenance, Overhaul, Garage and Running Repairs. London: Temple Press, Limited. [Price 2s. net.]

Industrial Electrical Measuring Instruments. By KENELM EDGCUMBE, M.Inst.C.E., M.I.E.E. Second Edition, revised and enlarged. London: Constable and Co., Limited.

Italian Sea Power in the Great War. By ARCHIBALD HURD. London: Constable and Co., Limited. [Price 2s. net.]

The Production and Treatment of Vegetable Oils, including Chapters on the Refining of Oils, the Hydrogenation of Oils, the Generation of Hydrogen, Soap-Making, the Recovery and Refining of Glycerine, and the Splitting of Oils. By T. W. CHALMERS, B.Sc. London: Constable and Co. [Price 21s. net.]

THE INDUSTRIAL RECONSTRUCTION COUNCIL.—Tuesday, February 11, at 6 p.m., in the Hall of the Institute of Journalists, 2 and 4, Tudor-street, E.C. 4, a conference on "Industry and Educational Reconstruction" will be held under the auspices of the Industrial Reconstruction Council. The opening address will be given by Mr. F. W. Sanderson, M.A., Headmaster of Oundle School. Questions and discussion will follow. No tickets are necessary.

INDUSTRIAL NOTES.

In August, 1917, say the Board of Trade, a large section of the railway employees made a demand for an 8-hour day. At that time it was refused, but the Government promised that a claim for a shorter working day could be put forward immediately after the cessation of hostilities, and that it would then have the sympathetic consideration of the Government. In consequence of this promise the principle of an 8-hour day for all members of the wages staff on the railways was conceded in December last, as stated on page 676 of our issue for December 13. What the Government granted under this arrangement was an 8-hour working day, and that, where time was allotted for meals, it was to be exclusive of the 8 hours, and this was accepted by the unions concerned.

In December the unions put forward further demands, including increased wages and improved conditions of service aside from the 8-hour day. These matters are to be considered at a meeting next week between members of the Railway Executive Committee and the men's unions. In the meanwhile existing conditions of service, apart from the 8-hour day, are to remain unaltered.

Notwithstanding this agreement with the responsible unions, certain employees on the Underground and the London, Brighton and South Coast Railways have taken it upon themselves to strike, and to demand that the time allowed for meals shall now be included in the 8-hour day. If this demand were acceded to, it would mean that these men would work only 7 hours or 7½ hours per day, and if this arrangement were extended to other railways it would reduce the working day in some cases to as low as 6½ hours.

It is quite clear that what is now demanded by the small section of men who are on strike is contrary to what has been agreed with the unions, and it is greatly to be regretted that this sectional disturbance, which so seriously interferes with the travelling public, and for which there can be no possible justification, should have occurred.

In reply to a letter dated last Tuesday received from Mr. J. Bromley, general secretary of the Associated Society of Locomotive Engineers and Firemen, Mr. Bonar Law wrote on the same day as follows:—

"The strike of a section of the men engaged on some of the London railways was undertaken on the ground that time allowed for meals should be included in the 8-hours day. When the Cabinet agreed to an 8-hours day it was clearly stated that it should be an 8-hours working day. The President of the Board of Trade therefore had no power to agree to any other arrangement, and I have before me the actual agreement, dated the 30th January, 1919, which is signed among others by yourself, and in which it is laid down in the most explicit terms that the condition as to an 8-hours working day agreed to by the Cabinet had been accepted. In these circumstances there is, it seems to me, no room for any misunderstanding, much less for any charge of a breach of faith, and I am sure that no useful purpose could be served by my seeing you in regard to it.

"If you have anything new to bring forward in regard to the situation I suggest that you should communicate with the President of the Board of Trade, who is acting in this matter for the Government.

"Let me add that apart altogether from the merits of the dispute, the sudden and irregular way in which it was begun has had the effect of causing the greatest possible amount of inconvenience and distress to the whole community."

Since our last issue the strike on the Clyde has continued, but owing to the firm action of the Government in sending the military to occupy the principal points in Glasgow and neighbouring cities, and to the fact that the three principal leaders of the strikers have been arrested, matters have quieted down somewhat and there has been a consi'er'ble resumption of work in several engineering establishments.

It is announced as a clear indication of the course of events that Messrs. Yarrow and Co., who, besides their works on the Clyde, at Scotstoun, also own similar but smaller works in Vancouver, on the Pacific Coast, intend gradually to decrease their output on the Clyde and to increase that of their Vancouver establishment. Messrs. Yarrow transferred their yard and engineering works from Poplar to the Clyde about twelve years ago, their object being to save on the cost of production, thus facilitating competition with foreign yards and works, by being nearer to British sources of supply of raw materials and coal. Their intention of ultimately leaving the Clyde, if it matures, will be a serious blow to the country; it was probably arrived at some time ago, and, we feel sure, was not reached without much heartburning. It would show that the unruly element which reigns on the Clyde, although, so far as we can gather, small in numbers comparatively, has had for many months past sufficient influence over the operatives to lead to periods of grave unrest, to consequent disruption in the work in progress, and to heavy outlays which have more than counterbalanced the advantages of less costly raw materials and coal.

It is to be hoped that the men, not only on the Clyde, but in other centres, will listen in good time to their best interests and cease to give ear to strike leaders, outsiders in many instances and of foreign extraction in some, who attribute to themselves the title of mediators, a title to which they never have had any right.

The strike in Belfast is still in progress, and the matters in dispute have been receiving the unremitting attention of the City Council. One of the latest suggestions, put forward by Mr. W. Gibson, Independent Unionist, is to the effect that the men should on alternate weeks work at 44 hours and 47 hours, pending a final settlement.

The Joint Trades Committee representing the engineering, shipbuilding and allied trades met at Barrow last Monday, and decided to call a mass meeting of the men for taking a vote on a 44-hour or a 40-hour week.

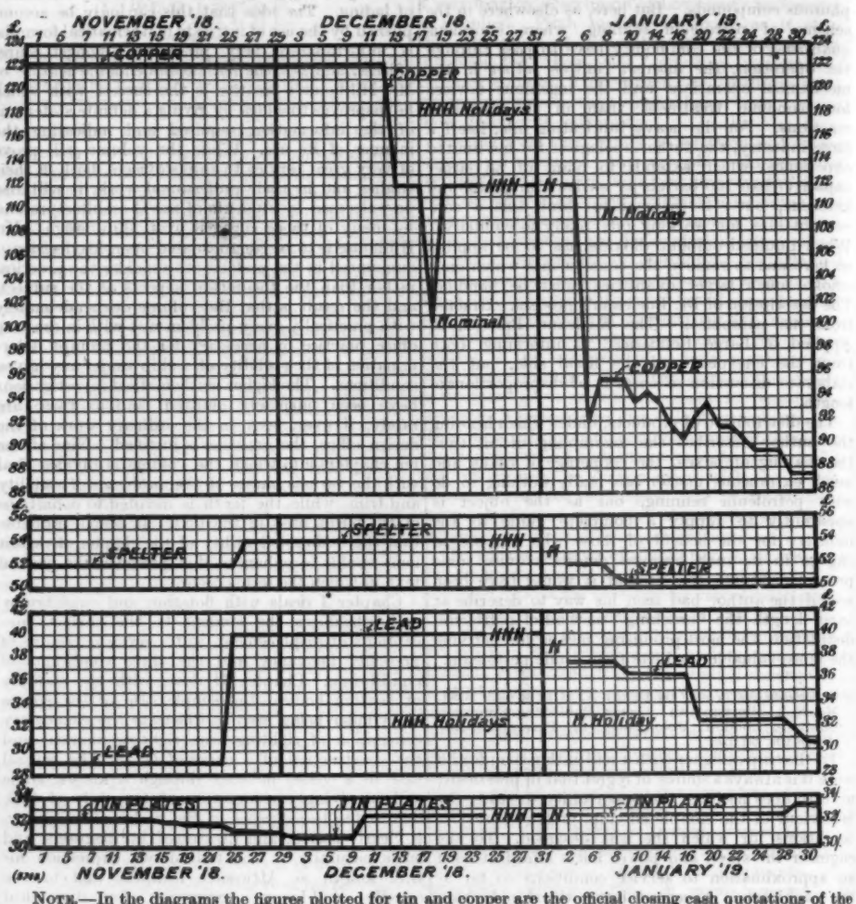
Mr. J. T. Brownlie, chairman of the Executive Committee of the Amalgamated Society of Engineers, issued, on Monday, an official statement to the effect that the Executive Council of the Amalgamated Society of Engineers have had under consideration the grave national situation created by the various unofficial strikes that have taken place throughout the country, arising out of the introduction of the 47-hour week. The Executive Council disapprove of all unofficial strikes and stoppages of work, and urge upon all members to resume work immediately, and thus enable responsible trade union executives to enter immediately into negotiations with the Employers' Federation with a view to obtaining redress of any grievances arising out of the introduction of the 47-hour week.

The Executive Council strongly deprecate the continuance of unofficial action by their members, and, whilst fully realising that during the deplorable period of the war for a variety of reasons it was necessary to deal leniently with those responsible for such unofficial action, they are conscious, in the interests of the trade union movement, that a firm stand has got to be taken. The Executive Council therefore appeal to all members in the London area to ignore the decision arrived at on January 31, at a meeting in Central Hall, Westminster, and in the interests of the society to continue at work, and utilise the machinery of the organisation to secure redress of any gri vances that may exist.

A conference of London and district trade unions, attended by nearly 100 delegates, was held at the Trades Hall, Blackfriars-road, last Monday, to discuss the 47-hour week demand. At the close, Mr. Stennett, London district secretary of the Carpenters and Joiners' Union, who presided, stated that a resolution had been carried by 68 votes against 39 calling upon the Government at once to intervene in the industrial disputes on the Clyde, in Belfast, and in London, with a view to putting into force through an Act of Parliament a national 40-hour week; in the event of refusal by the Government to intervene, a national down-tools policy

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

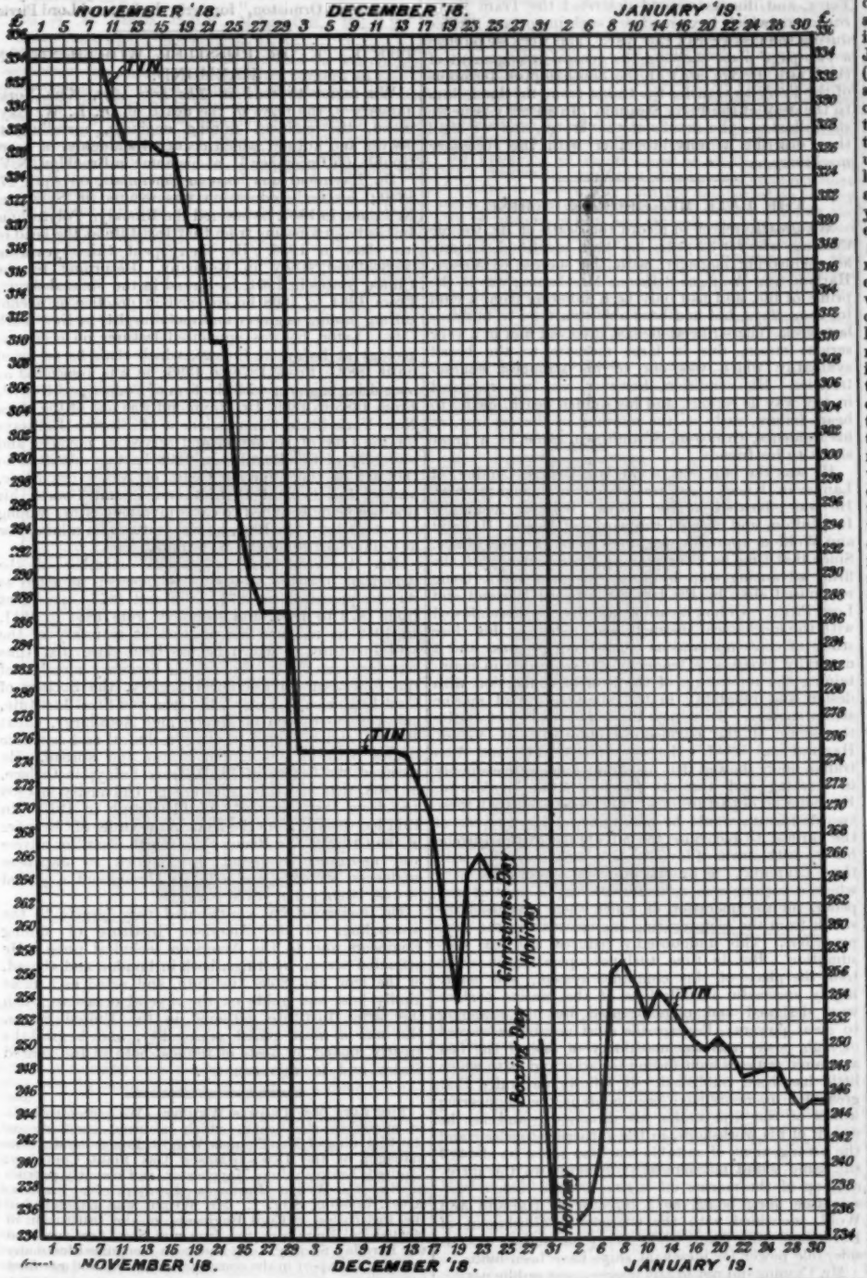
(Specially compiled from Official Reports of London Metal Markets.)



Note.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange, as far as they have been reported, for "fine foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. The prices are per ton. The price of tin-plates is per box of I.C. cokes free on board at Welsh ports. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each. On July 7, 1916, the Minister of Munitions issued a list of maximum prices and regulations governing the dealing in certain metals, &c.; thus the price of hematite pig-iron was fixed at 6*l.* 2*s.* 6*d.*, Scotch at 5*l.* 14*s.*, and Cleveland at 4*l.* 11*s.* 6*d.* per ton. Ship-plates were priced at 11*l.* 10*s.*, and heavy steel rails at 10*l.* 17*s.* 6*d.* per ton. (For official regulations see page 45, vol. cii.) A new series of prices for iron and steel has been issued, and appeared on page 646 of our issue of December 6, and on page 23 of our issue of January 3. The Minister of Munitions has also issued certain regulations controlling the prices and dealings in non-ferrous metals; these restrictions were removed on December 17.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially compiled from Official Reports of London Metal Markets.)



of all engineering trades in the London district was called for Thursday, February 6.

The Ministry of Labour had submitted to them last Tuesday two resolutions which were passed at meetings in London on Monday evening, demanding that the Government should at once intervene in the labour disputes on the Clyde, in Belfast and in London, with a view to introducing legislation to secure a national 40-hour working week "with the object of absorbing unemployment." The resolutions were passed at an unofficial conference of delegates of engineering trade unions in London and at a conference of the London members of the Electrical Trades Union. The resolutions included a statement that in the event of the Government refusing to intervene in the Clyde, Belfast and London disputes a general cessation of work was to take place yesterday. In the case of the Electrical Trades Union it was intended to bring about a stoppage of the power stations in London.

The deputation which conveyed the resolution on behalf of the engineering trades consisted of Mr. S. Stennett, London district secretary of the Carpenters and Joiners' Union and Mr. W. J. Webb, London district secretary of the Electrical Trades Union, accompanied by two other delegates. No officials or members of the executives of the other trade unions involved were present, and so far as the Ministry of Labour were concerned no communication in support of the resolutions had been received from any of the executives of the trade unions. On the contrary, the Ministry understood that the executives of the trade unions were opposed to the action suggested. The members of the deputation who came on behalf of the Electrical Trades Union were Mr. W. J. Webb, London district secretary, Mr. C. E. Stavenhagen, and another member of the executive, besides five other delegates.

In the case of the engineering trades, the executives of the unions were parties to an agreement entered into with the Engineering Employers' Federation providing for a working week of 47 hours. This agreement came into force on January 1. It is understood that in the application of this agreement certain questions had arisen affecting particular shops. These questions ought properly to be made the subject of discussion between the responsible officials of the trade unions and the employers' association concerned. In the case of the Electrical Trades Union, an agreement was arrived at between the electricity supply undertakings in the London area and the Electrical Trades Union, on January 3, under which a working week of 47 hours (48 hours in the case of shift workers) was agreed upon, and was put into force on February 1. It was not contended that any difficulties had arisen in regard to this agreement. If there were any such difficulties, the employers concerned were prepared to meet the union to discuss and adjust them. No communication had been received by the employers from the union, and the resolution suggesting a stoppage of work yesterday was not in any way one with which the employers were concerned.

The Ministry of Labour, on behalf of the Government, had from time to time been in touch with the executives of the trade unions in connection with the various difficulties that had arisen throughout the country. The agreements as to the change in hours had been made by employers' federations and responsible trade unions, and the Ministry had received intimation from the executives of some of the principal trade unions that the present difficulties were of a character which could be dealt with effectively only by the Executive Councils of the unions. These bodies themselves appreciated the fact that it was their responsibility to enter into agreements and to discuss with the employers any questions that might arise in connection with those agreements. They were aware that the services of the Ministry of Labour were at their disposal if they should desire to avail themselves of those services, but in the meantime they concurred in the view of the Government that present circumstances, due as they were almost wholly to unofficial strikes, did not justify Government intervention.

The following Regulation was made last Wednesday by Order in Council under the Defence of the Realm Acts, with reference to the threat of a strike by the London electricians :—

"43C. With a view to affording to the public similar protection in relation to the supply of electricity to that conferred in relation to the supply of gas and water by Section 4 of the Conspiracy and Protection of Property Act, 1875, the following provision shall have effect :—

"Where a person employed by a Government Department or by a municipal authority or by any company or contractor, upon whom is imposed by Act of Parliament the duty, or who have otherwise assumed the duty, of supplying any city, borough, town or place, or any part thereof with electricity, wilfully and maliciously breaks a contract of service with that department, authority, company or contractor, knowing or having reasonable cause to believe that a probable consequence of his so doing, either alone or in combination with others, will be to deprive the inhabitants of that city, borough, town, place or part, wholly or to a great extent of their supply of electricity, he shall be guilty of a summary offence against these regulations."

Any person guilty of an offence against this regulation is liable to six months' imprisonment, with or without hard labour, or to a fine of 100*l*., or to both such imprisonment and fine.

Any person who attempts to commit, or solicits, or incites, or endeavours to persuade another person to commit such an offence, or procures, aids or abets, or does any act preparatory to the commission of such an offence, is liable to like penalties.

At a meeting held last Tuesday between the President of the Board of Trade, the Minister of Labour, and representatives of the Railway Clerks' Association, an agreement was reached under which it was provided that the Government would accord full recognition to the association, this latter to make arrangements for ensuring the autonomy of the supervisory grades within the association which the Government consider necessary for the preservation of discipline and the public safety.

The President of the Board of Trade then arranged for a further meeting this week between representatives of the Railway Executive Committee and the Railway Clerks' Association, for the purpose of giving consideration to the application of the principles which had been agreed upon.

Our contemporary *The Iron Age*, New York, has addressed four queries to leaders of the American iron and steel trades on important problems of the moment. We need not print these queries, the following replies give their bearing :—

Mr. E. W. Mudge, of Edmund W. Mudge and Co., Pittsburgh, expressed the following opinion :—

"Employers and employees for some years past were

coming closer together in industry. The war, no doubt, hastened this, and among all classes and kinds of peoples, closer relations were brought about through war activities. I consider that all business to-day has two very important partners, in addition to the stockholders; they are the employees and the Government. I do not consider that there is any new labour problem.

"Government control during the war, without a question, was a necessary evil. If continued after the war, it would be a calamity. Very considerable public service was rendered by men of affairs, who devoted their service to the Government during the war, and considerable good should result from their efforts.

"Satisfactory laws should be enacted by our Government (possibly others repealed), and that would be of great help in extending our own trade and preventing undesirable competition. I do not feel as if we should have any trade relations with the Central Powers. I do not think they are worthy of any consideration.

"The outlook for foreign trade should be very good, if we are able to get sufficient ships and operate them on an economical basis, so as to compete with other nations. There is no reason why we should not do the major part of the world's trade if we are able to meet competitive conditions. Our domestic situation, over a longer or shorter time, will be affected very seriously by what foreign business we can do. I believe that after peace is signed and conditions are improved throughout Europe the reconstruction demand will be of considerable importance."

Mr. C. D. Dyer, vice-president, Shenango Furnace Company, Pittsburgh, wrote as follows:—

"If we revert to the conditions which prevailed after the Civil War as an available precedent, we are in for a recession of values which, among business men, is likely to be brought about in orderly adjustment by the working of natural laws, bringing values down to a new level which may have no reference to any conditions which prevailed in the twenty years preceding 1916.

"The intelligence of our labour leaders has been demonstrated on more than one occasion, and it seems improbable that these men, with the knowledge and experience gained, coupled with their power developed within the past few years, will not lend a hand in enabling business to reach solid conditions.

"There is undoubtedly a large amount of construction and other demands now suspended and awaiting the time when prospective investment buyers will feel that we have arrived on a new normal basis of values which will warrant going ahead. In the meanwhile, we think that history will repeat itself and that business will be at a standstill more or less long.

"Certainly this country has a right to look forward to a long period of prosperity after the adjustment in values has been reached."

The French Society for Encouraging National Industries, says *Le Temps*, for December 22, has passed a resolution to the effect that, although the intervention of the State in industrial spheres may have been necessitated by the requirements of national defence, in view of the fact that an undue extension of this intervention would be fraught with danger to the economic future of the country, the Government should withdraw all measures which impede the free progress of industry, agriculture and trade; and that those measures which may have to be enforced temporarily, such as those regarding the provision of raw materials, should be drawn up by all the Allies in common and should be applied to all.

A second resolution refers to the dangers of State control in factories. It is contrary to the principles of economic freedom, the resolution states, to maintain after the cessation of hostilities an economic autocracy, and the action of the public authorities in transforming munition factories into ordinary, industrial concerns while maintaining State control, is likely to produce a crisis of super-production and to absorb a great number of specialists who would otherwise return to their ordinary industrial work.

The Pitwood Order, 1918.—Pursuant to paragraph 3 of the Pitwood Order, 1918, notice is given by Mr. J. B. Ball, Controller of Timber Supplies, Board of Trade, that as and from the 17th inst., the maximum prices at which pitwood imported from outside the United Kingdom may be bought or sold or offered for sale or purchase in the United Kingdom shall be as follows: (1) Pit props cut to lengths delivered on rail at mine sidings, or, failing rail connection, at mine premises (per 100 lineal feet): 3½ in., 33*s.*; 4 in., 42*s.* 6*d.*; 4½ in., 50*s.* 0*d.*; 5 in., 60*s.*; 5½ in., 73*s.* 6*d.*; 6 in., 88*s.*; 6½ in., 101*s.* 6*d.*; 7 in., 120*s.* Terms, 2½ per cent. discount on usual monthly account. (2) Pitwood imported from France, Portugal or Spain, delivered ex-ship at South Wales ports, 60*s.* per ton for hardwood and 65*s.* per ton for softwood.

THE SOUTHAMPTON TRAIN FERRY.

In our issue of the 24th ult. (*vide* page 119 *ante*), we commenced an account of the Southampton Train Ferry, and illustrated and described the Train Ferry Steamers, which have rendered such important service during the last year of the War. This week we publish a two-page plate showing the general arrangement of the Train Bridge used at the Southampton terminus of the Ferry to transfer the trains from the land lines to the deck of the Ferry Steamer. In an early issue we shall illustrate the details of this bridge, and we shall then describe it fully, together with the accessory machinery.

THE LATE MR. GEORGE CUMING.

We greatly regret to record the death of Mr. George Cuming, who for 32 years has been identified, latterly as engineering manager, with the success of Messrs. Harland and Wolff, of Belfast. Mr. Cuming was in the prime of life, and had only been suffering from a chill for some days, but had been able to attend to business last week. The strike at Belfast involved him in a very serious strain, due in large measure to the broad sympathy which was one of his strongest characteristics. His condition, however, was not regarded in any way as serious, and his sudden death, owing to heart failure, early on the morning of the 1st inst. at his residence, Ormiston, Strandtown, came as a great shock to his friends.

He was the only son of the late George Cuming, of Lannevan Knock, and was in his forty-eighth year. He was educated at the Royal Belfast Academic Institution, and entered the works of Messrs. Harland and Wolff as apprentice-engineer when 16 years of age. Since that time he has remained continuously with the firm, advancing step by step, his great merit being recognised alike by the late Sir Edward Harland and Lord Pirrie. Of him it can be said that he was endowed with the mechanical instinct, and, aided by his close study of contemporaneous engineering progress and a naturally progressive tendency, he succeeded in maintaining the reputation of the firm in connection with design and reliability in the manufacture of marine steam engines. To review his work would be to write the story of the engineering enterprise of Messrs. Harland and Wolff. His work for Atlantic and Australian liners showed that his strong aims were economy in working and absolute freedom from breakdown. He made no departure until he was satisfied that these two desiderata would be maintained. He was one of the earliest to recognise the advantage of the turbine for use with steam of low pressure, and, beginning with the "Laurentic," he produced several sets of machinery where a turbine was used for driving a central propeller, for the operation of which there was used the steam from the reciprocating engine working the wing propellers. This undoubtedly reduced the coal consumption. But in time turbines operating in series took the place of this combined system, and many highly successful installations of the marine turbine were designed and manufactured by him, ranging to great powers. Perhaps the most notable in respect of high power was the machinery of one of the fast armoured cruisers built during the war, and as to which little has been published. It follows naturally that great developments have been made in the engineering works of the firm under his direction; and in the design of his workshops, in the gathering together and the arrangement of suitable machine tools, he showed the same sound mechanical judgment. In the introduction of the marine oil engine he also took a considerable part, being, as a director of Harland and Wolff, identified with the Glasgow establishment of Burmeister and Wain, where many oil engines of considerable power for merchant ships have been built.

Mr. Cuming did not in any degree court public notice, and it was only in connection with the visits of institutions to Belfast that he was induced to become a member of these. Thus in 1906 he became a member of the Institution of Mechanical Engineers, and in 1908 a member of the Institution of Naval Architects. He did not contribute to the literature of these Institutions, but those members who visited the works on the occasion of the Irish meetings of their Institutions will recall the quiet urbanity and kind wish to give helpful information, and withal the great force of character that lay behind this gentleman of high rectitude. In 1917 he was made an Officer of the Order of the British Empire, but all realised that this was a poor recognition of his work, and many hoped and expected that a more adequate acknowledgment would be given. For years he has been a managing-director of Messrs. Harland and Wolff, and since Mr. Kempster took up residence on the Clyde to attend to the affairs of the company there he has been the senior managing-director. His loyalty to the firm only intensified his desire to ensure friendly relations with the workers, and it is an illuminating fact that, on hearing of his death at one of the great mass meetings of the strikers, all present paid a marked tribute to his memory. On Tuesday, as his funeral passed near to one of the mass meetings, hundreds left to join in paying their last respects to their old chief. He was unmarried. Only recently he purchased "Ormiston," formerly the home of Lord Pirrie.

THE LATE DR. ROSSITER WORTHINGTON RAYMOND.

We regret to read in *The Iron Age*, New York, January 9, the news of the death of Dr. R. W. Raymond, the eminent mining engineer, metallurgist, lawyer and author, which occurred suddenly, of heart trouble, on December 31, at his home in Brooklyn, N.Y.

Dr. Raymond was born in Cincinnati, on April 27, 1840; his early education was secured in Syracuse, N.Y., and in 1857, he entered the Brooklyn Polytechnic Institute, graduating from that Institute at the head of his class in 1858. He then spent three years in professional study in Germany. Returning to the United States in 1861, he served in the Federal Army. From 1864 to 1868 he engaged in practice as a consulting mining engineer and metallurgist, in New York City. Later, he was appointed lecturer on economic geology at Lafayette College, which chair he occupied until 1882. From 1875 to 1895, he was associated as consulting engineer with the firm of Cooper and Hewitt. From 1885 to 1889, Dr. Raymond was one of the three New York State Commissioners of Electric Railways for the City of Brooklyn, and served as member and secretary of the Board. In 1898 he was admitted to the bar of the Supreme Court of New York State, and of the Federal District and Circuit Courts, his practice being confined to cases involving either mining or patent law. In 1903, he was lecturer on mining law at Columbia University, New York.

Dr. Raymond was an original member of the American Institute of Mining Engineers; he acted as its vice-president in 1871, 1876 and 1877; president from 1872 to 1875, and secretary from 1884 to 1911. In 1912 he resigned his position as secretary of the said Institute, of which he has been since that time secretary emeritus. He was an honorary member of the American Phylosophical Society, the Society of Civil Engineers of France, the Iron and Steel Institute, and the Institution of Mining and Metallurgy, Great Britain, and belonged to other technical and scientific bodies both in the United States and abroad. He received the degree of Ph.D. from Lafayette College, in 1868, that of LL.D. from Lehigh University in 1906 and from the University of Pittsburgh in 1915. In 1911 he received from the Mikado the Order of Chevalier of the Order of the Rising Sun, fourth class, for advice and assistance rendered in America to Japanese engineers, students and officials throughout a period of over twenty-five years.

Dr. Raymond has contributed very largely to the proceedings of the American Institute of Mining Engineers and to the American technical press. He attended several meetings, both in London and abroad, of the Iron and Steel Institute, and acted as a most kindly host and guide on the several occasions when the latter Institute gathered in the United States. His was a most genial personality, and he will be greatly missed by hosts of friends, both in the United States and in this country.

The late Mr. Thomas Wright.—We regret to have to announce the death, which occurred suddenly on the 31st ult., of Mr. Thomas Wright, late general works manager of the Dowson-Mason Gas Plant Company, Limited, Levenshulme, Manchester, and recently partner in Smeeton-Wright Furnaces, Limited, 56, Victoria-street, London, S.W. 1. Mr. Wright was a member of the Institution of Civil Engineers, of the Institution of Mechanical Engineers, the Iron and Steel Institute and the Faraday Society. He had been recognised for many years as an expert in the construction of coal and gas-fired furnaces.

Calcium Carbide Preparation in Solid Carbon Dioxide.—A curious, though not profitable way of making calcium carbide without the aid of an electric furnace is described by F. Fichter, in the *Helvetica Chimica Acta* (1918, page 431), a journal which was started last year and is published in Basle and Geneva. It is a lecture experiment, and the raw materials are metallic calcium and carbon dioxide, the latter in the form of a snow of the solidified gas. The powdered metal and the CO_2 snow are mixed and placed on a compressed layer of CO_2 snow resting on an iron tray; some burning calcium is then dropped on the mixture in order to start the reaction. Calcium carbide and also some calcium nitride are formed; an excess of CO_2 keeps the nitride formation down. The experiment is a modification of the reduction of solid CO_2 by magnesium or aluminium which was described by K. Brunner in 1905; in this instance carbon is reduced, but carbide is not formed. That carbon can be reduced from carbon dioxide by means of metallic potassium or sodium has long been known; in that case, however, the gaseous CO_2 is passed over the heated metal, whilst in the modifications mentioned the reduction apparently takes place in the snow, in reality also in the gas, however, though under different conditions.

THE NAVIGATIONAL MAGNETIC COMPASS CONSIDERED AS AN INSTRUMENT OF PRECISION.*

By M. B. FIELD, O.B.E., M.Inst.C.E., M.I.E.E.

SOME years ago, I had occasion to discuss the subject of navigational compasses with a friend—a well-known member of this Institution—and after perhaps an hour's conversation, my friend remarked that he had no idea that there was so much to be said about "the compass"; that he had pictured it as a nicely-made magnetic needle attached to *some* sort of a card, the whole supported on a pivot and enclosed in *some* sort of a case. He had thought that such description adequately summed up, in brief, the mariner's compass.

There may be some present to-night who are of the same opinion; if that be so, I shall hope to show them that the problems involved are of greater variety than they imagine. We have, for example, problems of an essentially practical nature in mechanics and mechanical construction, the wear and tear of materials, the effects of vibrations of an exceedingly complex character; considerations of fluid friction, viscosity, and fluid motions; terrestrial magnetism; the magnetism of iron and steel; the fields of force and systems of magnetic potential due to complicated arrangements of magnets or the equivalent; and so forth.

I need hardly say that it will be necessary to restrict ourselves to-night to a few of these problems, and we must pass by many without so much as a reference to them.

The title of this paper is the "Navigational Magnetic Compass Considered as an Instrument of Precision," with special emphasis laid upon the word "navigational."

Ordinarily, we expect a magnetic needle to tell us the direction of the magnetic force in the region in which it is placed.

If the field in question is the undisturbed field of the earth—undisturbed, except for the necessary local disturbance which the needle itself produces—we may expect any well-constructed and suitably supported needle to give us correctly the direction of the meridian.

Its precision will depend upon the accuracy of workmanship, and freedom from pivot friction, and its error may be reduced to the same order as the error of unaided observation.

My friend's remarks were no doubt prompted by this conception of the functions of a compass.

In the case of the navigational compass very much more is required.

In the first place, we observe that the ship itself is magnetic, and that the magnetic force at any selected station not only differs in direction from the meridian, but that as the ship swings round, the force undergoes cyclic changes, both in magnitude and direction.

On further investigation, we note that the amount of the deviation of the magnetic force from the plane of the meridian not only depends upon the course the ship may be steering at the time, but also upon her absolute geographical position.

Again, we find the ship's shape and proportions, the locality in which she was built, the direction of her head while under construction, in short her past history, and particularly her recently past history, are all factors that influence her magnetic state.

Thus, the duty we require the compass to perform is no easy one; surrounded as it is by disturbing influences, we require it to ignore every misleading suggestion and to point unhesitatingly to the magnetic north.

If we annul by magnets, or otherwise, the effect of all the magnetism of the ship, and this annulment remains effective on all courses, with the ship upright or listing, and at all parts of the earth, we obtain complete compensation; or, again, if we neutralise the east-westerly component of the ship's magnetism, and the neutralisation is effective under the above conditions, the compass is completely compensated.

In practice, we annul some of the components of ship's magnetism, and neutralise the east-westerly force of others, in such a way that the compensation is very nearly complete on all courses, no matter whether the ship be upright or not, and the correction remains good at all parts of the earth—provided the so-called permanent magnetism of the ship remains permanent, and the so-called induced magnetism is strictly proportional to the inducing force, and vanishes when the inducing force is withdrawn.

Unfortunately, we find that the permanent magnetism is not permanently "permanent," and the induced magnetism is not instantly "transient," and our complete compensation is to this extent incomplete.

FIG. 1.

Much of the permanent magnetism said to be "hammered" into the ship in the course of building is "shaken" out of her during her first few voyages, while magnetism of a semi-permanent character is "picked up" by a ship sailing for days together on a given course, and is only gradually lost, it may be over a period of hours, or even days, when the course is materially altered.

Further examples of permanent magnetism being "shaken" out of a newly-built ship, are furnished by the great change in the magnetic character of a new warship when undergoing gun-firing trials.

The precision of the navigational compass is, therefore, not only dependent upon the accuracy with which its "correctors" perform their function of compensating for the ship's normal magnetism, but it is also dependent upon what Lord Kelvin called "unpredictable irregularities due to variations of the permanent magnetism, and to retention of some of the transient magnetism when the inducing influence is past."

The possible occurrence of unpredictable irregularities affords no ground whatsoever for relaxing our efforts to render the compass—apart from such irregularities—an instrument of precision, and it is in this sense that the term is used in the title of this paper.

I need scarcely remind electrical engineers that no instrument—I care not of what type, or for what purpose—is altogether immune from unpredictable irregularities, and just as the painstaking observer is ever on the alert to detect an aberration, to measure its amount, and to trace its origin, so the careful navigator will be on the watch for changes of the magnetism of his ship, and will regularly avail himself of opportunities afforded of taking sun, moon, or star observations for the purpose of checking the readings of his compass.

The manner in which Lord Kelvin became intensely interested in the mariner's compass is characteristically told by him in his article on Terrestrial Magnetism and the Mariner's Compass, "Popular Lectures and Addresses," vol. iii. He began an article in *Good Words* in 1874, and after dealing with the historical portion of the subject, the article stopped—to be continued only after five years. The interval had been devoted by Lord Kelvin largely to the subject upon which he started to write his popular article.

He says:—

"The first part of this article was written five years ago. I then thought I had a pleasant and easy task before me—to describe a scientific instrument which was known to the Chinese 2,000 years before the dawn of science. . . . But when I tried to write on the mariner's compass, I found that I did not know nearly enough about it. So I had to learn my subject. I have been learning it these five years, and still feel insufficiently prepared to enlighten the readers of *Good Words* upon it when I now resume the attempt to complete my old article."

When Lord Kelvin broke off his article in 1874, he had arrived at the conclusion that the mariner's compass, as used in iron ships, ought to be an instrument of precision, but was not, and he set himself the task of devising a new compass which might fairly lay claim to be an instrument of precision.

In concluding the article, Lord Kelvin described, in the simple and effective words of which he was such a master, the improvements in the construction of the mariner's compass and its accessory apparatus which he had devised during the intervening five years.

In 1839, Airy (later Sir George Airy), Astronomer Royal, wrote one of his many remarkable papers in the Philosophical Transactions of the Royal Society, on the deviations of the compass in iron-built ships, giving the interpretation of carefully conducted experiments in the light of a mathematical theory—the whole investigation having been undertaken at the request of the British Admiralty. In the article, Airy propounded means for approximately correctly compensating a compass (with short enough needles, and small enough magnetic moment) for errors which arise, due to the ship's magnetism.

Airy's practical method of compensation was quickly adopted in the iron-built ships of the merchant service. Certain difficulties, however, soon became manifest to expert compass adjusters, arising from the use of magnetic correctors, and it was found impossible in certain cases to obtain a correct compensation.

For example, the celebrated steamship, the Great Eastern, was provided with a compass having an 11-in. needle, and after careful compensation in accordance with all the rules then laid down, very considerable errors were found when the ship's head occupied certain positions in azimuth.

As a matter of fact, errors of two kinds were being introduced by the design of compass employed, one depending upon the length of the needle, the other depending upon its magnetic moment.

In order that we may clearly appreciate this, some explanation is here necessary.

When selecting a suitable place for a compass station on board ship, due care is taken that the nearest iron is at a relatively great distance, so that if magnetised, it gives rise to a magnetic field at the compass station which may be regarded as uniform over a region considerably larger than that swept out by the compass needles when rotated on the card pivot.

Moreover, the nearest iron must be sufficiently remote to ensure that there is no sensible attraction of the needles due to magnetism induced in the iron by the needles.

When these conditions are duly observed, the position of equilibrium of the uncompensated card does not sensibly depend upon whether the needles be long or short, or whether their magnetic moment be large or small, but merely upon the direction of the resultant magnetic field acting at the compass station.

The compensation of the compass by Airy's method is effected by placing magnets and masses of iron near to the compass in positions calculated to produce magnetic forces in the region swept out by the card needles, which exactly counterbalance the deviating forces, due to the magnetism of the ships' ironwork.

In order that the system may not become unwieldy and impracticable, it becomes necessary to place magnets and iron masses of considerable size very near to the compass, in fact they are incorporated as part of the compass binnacle. See Fig. 1.

Now, the magnetic fields to which these give rise are by no means uniform over the region swept out by the needles of a long-needle card, with the result that a short needle will have a different position of equilibrium from that of a longer needle.

For example, it is usual to employ two cast-iron spheres attached to the binnacle for the correction of one of the effects of ship's magnetism, viz., the quadrantal effect. These spheres may be 8 in. diameter, placed on either side of the compass at about 12 in. from the card centre, and level with the card. They become magnetised by the earth's field, and behave so far as external points are concerned, as extremely short magnets of definite magnetic moment always pointing along the line of resultant magnetic force.

Now, we may draw the lines of magnetic force and lines of equal potential values due to such a system. Equipotential lines are exhibited in Fig. 2, on page 188, for the case where the line joining the centres of the spheres is E — W (magnetic); it will be seen that this field is by no means uniform. A uniform field would be represented by a family of straight parallel and equi-distant equipotential lines. We thus employ a non-uniform field, such as that shown in Fig. 2, to correct the compass for the deviation produced by a perfectly uniform field arising from some effect of ship's magnetism.

Fig. 3 shows the equipotential lines due to the magnetisation of the globes when the ship is steering a quadrantal course.

Fig. 4 represents the effect when the ship is on an easterly or westerly course. In all cases, Figs. 2, 3 and 4,

* Lecture delivered before the Institute of Electrical Engineers on January 9, 1919.

the interesting part of the field is where the dotted circles are drawn. This is the position of the compass card. The smallest dotted circle represents the area swept out by needles 4 in. long; the intermediate circle corresponds to 6-in. needles, the largest circle to 8-in. needles.

The un-uniformity in this region is sufficient to account for appreciable secondary errors when using needles of considerable length.

Fig. 5 illustrates the family of equipotential lines in the plane of the card due to a corrector magnet placed 20 in. below the card. In this case, the field of force is very nearly uniform over the region in which we are interested.

Again, another effect of ship's magnetism is compensated by what is termed the "Flinder's bar," a long, straight vertical bar 3 in. in diameter, perhaps 16 in. long, and only 10 in. from the card centre, the upper end being usually nearly level with the card.

Such a bar becomes magnetised by the vertical component of the earth's field, and gives rise to lines of equal potential in the plane of the card, as represented in Fig. 6—again a field of force very far from uniform.

Further, these iron correcting masses are sufficiently near for a needle of large magnetic moment to induce magnetic effects in the correctors, which, reacting upon the needle will sensibly effect its position of equilibrium.

We have then to remember that correctors, while introducing magnetic forces which neutralise those due to the ship, introduce additional forces which may produce deviations, depending on:—

(*a*) The length and arrangement of the magnetic needles.

(*b*) The magnetic moment of the needles.

In view of the difficulties experienced in the adjustment of the standard compass of the Great Eastern, the errors which arise from the length and arrangement of the needles were carefully studied experimentally by Commander Evans, and, mathematically, by Archibald Smith, the results of the investigation being given in the combined paper in the Philosophical Transactions, 1861.

By this investigation, the authors arrived at a remarkable result, namely, that by a certain arrangement of needles on a compass card, in place of a single needle, the errors due to length of needle very nearly disappeared, and that the particular arrangement necessary for the fulfilment of this condition was the very one which had been adopted in the construction of the standard Admiralty compass, entirely on account of other considerations.

The standard Admiralty compass card at that date was provided with four needles arranged as in Fig. 7.

The object of this particular arrangement was to ensure that the moment of inertia of the system about all diameters was the same, a condition favourable to the elimination of what was termed "wobbly" motion of the card.

The coincidence discovered mathematically and demonstrated experimentally by Smith and Evans, was that if the poles of the needles in the two needle card subtend 60 deg., or in the four-needle card are placed at equal distances measured circumferentially from the extremities of the 60-deg. chords, as, for example, in Fig. 7, the magnetic errors due to length of needle largely disappear.

For the purpose of producing steadiness, one naturally inclines to some method of fluid friction damping, but for definite practical considerations, to be later discussed, Lord Kelvin dismissed the idea of fluid damping. He rather sought to render the card inherently stable under ordinary sea-going conditions.

The other intensely practical considerations from the mariner's point of view were, as usual, prominently before Lord Kelvin. The card must stand rough handling, it should be capable of deformation and yielding to stresses and of recovery without damage. It must stand the weather of all climates, intense heat and cold, prolonged dryness and humidity without warping, while the pivot, jewel, or even the card itself, must be capable of replacement at a moment's notice, in case of emergency, by spares usually provided with the outfit; and this must be possible without liability of damage by a not very delicate-handed navigator under unfavourable conditions at sea.

I cannot do better than to repeat here Lord Kelvin's own words:—

"The problem of obtaining a compass which shall be steadier at sea, and shall also be better adapted for the perfect correction of the error due to the iron of an iron ship, or of cargo carried by the ship, requires:

"1. For steadiness a very long vibrational period with small frictional error.

"2. Short enough needles to allow the correction to be accurate on all courses of the ship for the place where the adjustment is made.

"3. Small enough magnetic moment of the needles to allow the correction of the quadrantal error to remain accurate to whatever part of the world the ship may go."

Lord Kelvin then proceeds to describe his well-known compass card and compass; speaking of the card, he states that the weight of his design was one-seventeenth part of the weight of the ordinary 10-in. card hitherto in common use in the best-found merchant steamers, which was about 6 oz. Further, that the magnetic moment was only about one-thirteenth part of that of the two needles of the ordinary 10-in. card as made at that date, and was so small that the error due to its inductive influence on the iron globes used for correcting the quadrantal error was practically insensible.

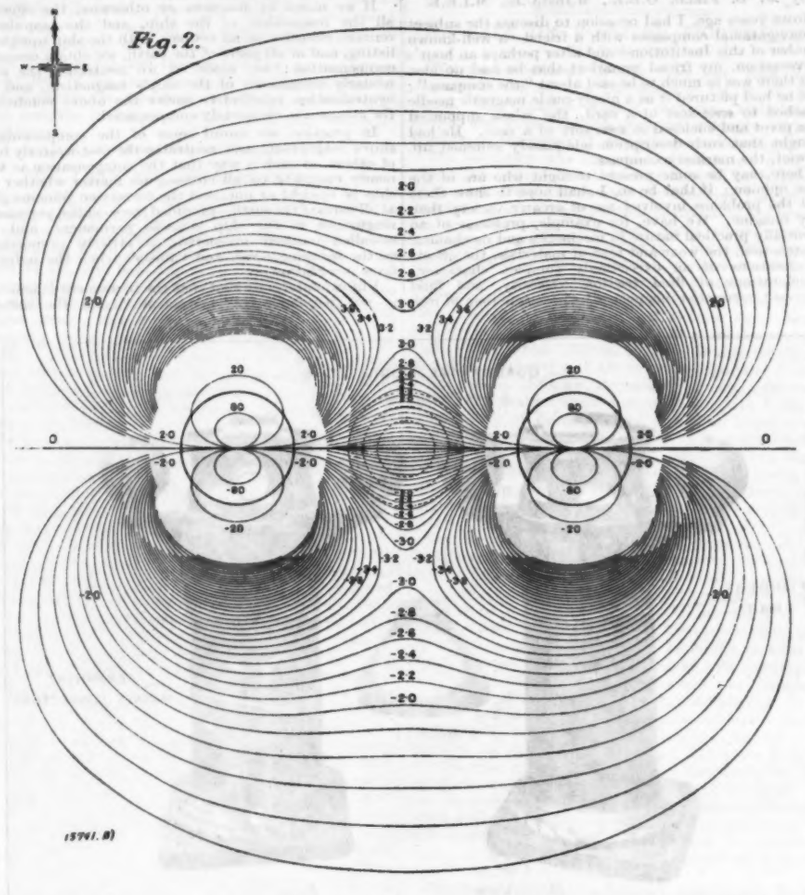
As an alternative to the "dry" compass just described, we have the liquid or spirit-filled compass.

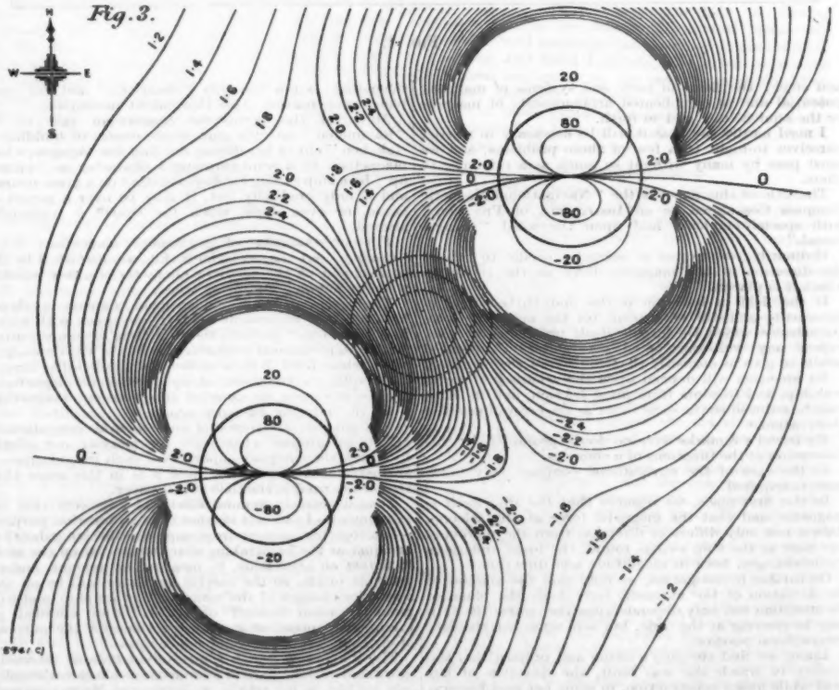
The liquid type is undoubtedly favoured by some navigators, on account of its extreme deadbeatness, especially for steering purposes.

In small light craft, it becomes a necessity in rough weather, and whenever space restrictions do not permit of the use of a 10-in. dry card, the spirit compass should be resorted to.

This type, however, is by no means perfect, and suffers from the disadvantages that it is very much overdamped, necessitating an undesirably great magnetic moment, and, consequently, a great mass in the moving system.

Some idea of the strength of needles and the great masses employed in the cards of liquid compasses may





be formed by a perusal of the following table, comparing a 10-in. Kelvin card (dry) with various makes of card for liquid compasses (see table in next column).

In order to reduce the requisite magnetic moment, one naturally considers how to reduce the moment of inertia of the card.

Comparison of Standard 10-in. Dry and some Liquid Cards.

	Diameter of Card.	Max. Length of Needle.	Weight in Air.	Moment of Inertia.	Magnetic Moment.	Time of Half Period at Glasgow.
	in.	in.	grms.	c.g.s.	c.g.s.	sec.
Standard 10-in. "dry" card ..	10	3½	13	1,200	300	16·0 (in air
Naval liquid compass	6½	3½	82	1,060	1,600	16·0*
U.S.A. naval ditto (Ritchie).. ..	7½	4½	100	2,910	2,400	21·0*
Ritchie	9	7½	152	3,270	5,160	20·5*
Common steering compass.. ..	9	7	135	5,110	2,300	30·0*

* Liquid: 50 per cent. alcohol, 50 per cent. water, at 20 deg. C.

In the case of the liquid compass the card is deviated 45 deg. and released; the time interval between the first and second transit of N-point of card past the lubber line is the half period.

"poles" of the needles in the two-needle card should subtend an angle of 60 deg. at the card centre.

This was given by him in his 1861 paper in the Transactions of the Royal Society, London.

In elaborating this theory, Smith assumed that the magnetism might be considered as concentrated at points near the ends of the needles, hence the expression "poles."

While this is legitimate when we are considering the couple exerted in the needle in a uniform field, it is not strictly legitimate when we are dealing with non-uniform fields.

If instead of considering charges of $+m$ and $-m$ at or near the ends of a needle, we consider that there is a charge spread over the whole length of the needle (the exact character of the distribution being in the meantime unknown), in other words, if we assume that there is "magnetic matter" on or in each element of the needle, how should the Archibald Smith theory be modified?

Let us assume that the needle is symmetrically magnetised about its centre O and that in an element δx we have an amount of magnetic matter $(\sigma\,\delta x)$; let this element be situated at a distance x from the centre.

If, now, we multiply $(\sigma\,\delta x)$ by the cube of the distance x; add up such values for all the elements comprised in the needle; divide the summation by the reading of the balance will be the quantity of magnetic matter in centimetre-gramme-second units.

Next consider the transverse boundary planes are infinite current sheets with current flowing away from us in the left-hand plane, and towards us in the right-hand plane as shown by the crosses and dots; suppose that the current in the current sheets is uniform and has a density of $\frac{10}{4\pi}$ amperes per centimetre; we shall have no magnetic field in the space A to the left of the current sheets, no force in the space B to the right of the sheets, and a uniform field of unit intensity directed vertically downwards in the space between the sheets.

We may thus picture to ourselves a magnetic balance for weighing the amount of magnetic matter on each element of the needle.

Such a balance is represented conventionally in Fig. 8.

In a practical apparatus, however, we have to get round the difficulty of using infinite current sheets.

Fig. 9 shows pictorially a further development of the balance by which we arrive at the desired result. Here we have two cylindric current sheets of convenient dimensions as a substitute for our infinite plane sheets.

These cylindrical sheets are obtained by taking a piece of brass tube as a former and overwinding by a layer of fine wire uniformly spaced, so that current flows uniformly down the outside surface of the cylinder and uniformly up the inside surface.

If the distance between the cylindrical current sheets be small compared with their radii, we have: no field inside the inner cylinder; no field outside the outer cylinder; and practically a uniform field in the annular space between the current sheets, the lines of force being circles concentric with the cylinder and lying in transverse planes.

A small hole is drilled through the sheets through which the needle under test passes. The magnetic matter situated in the annular space between the sheets is urged laterally by the magnetic force existing there, and the force is weighed by the small adjustable weight in the balance arm.

Another form of apparatus which I have found convenient for the purpose is shown in Fig. 10.

In this, the force on the element is balanced against the earth's directive force on the whole needle. The complete stand is mounted on a graduated turntable, and rotated in azimuth until balance is obtained.

If H = earth's horizontal force.
M = magnetic moment of the needle.

Fig. 4.

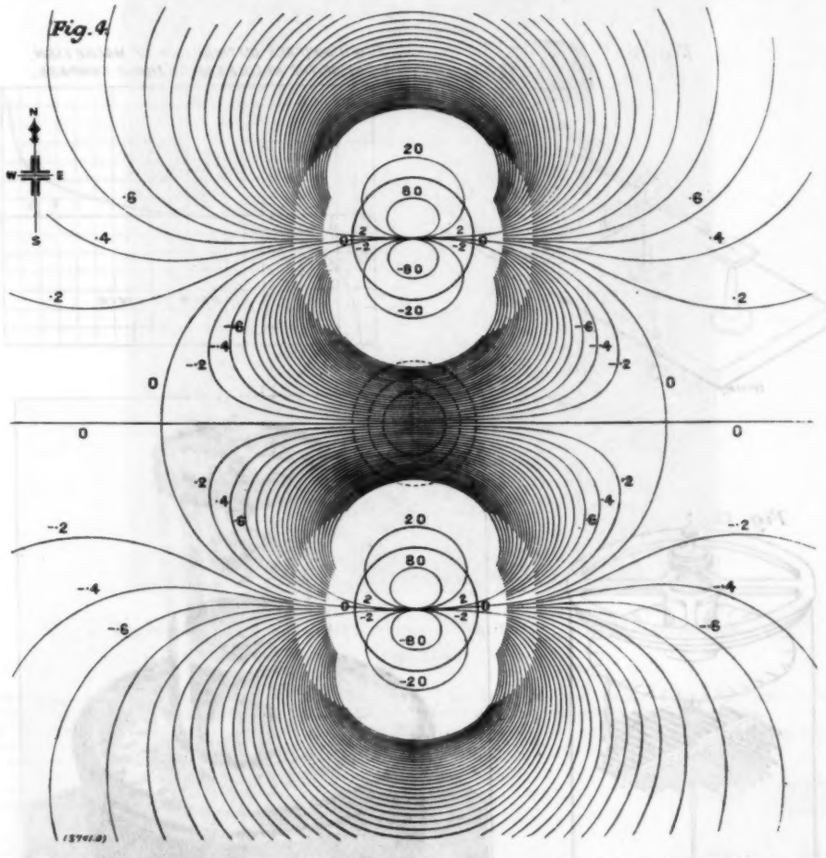


Fig. 5. INTERSECTION OF EQUI-POTENTIAL SURFACES BY PLANE 50 CMS. ABOVE MAGNET & PARALLEL WITH AXIS.

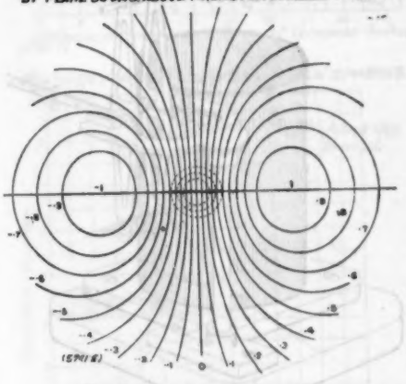


Fig. 6.

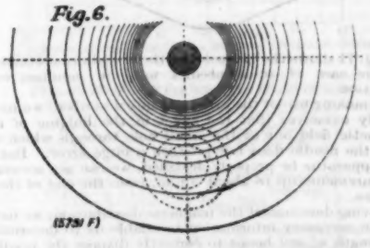
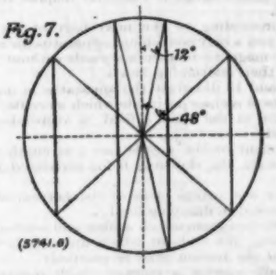


Fig. 7.



But when the moment of inertia has been reduced to the furthest possible limit, the magnetic moment must still be considerable, if we are to have a moderately quick-acting card. The reason is that the effective moment of inertia does not reside solely in the card, but partly in the fluid.

As the card oscillates, the liquid in the immediate vicinity of the card is dragged backwards and forwards with it, and this has the effect of apparently augmenting the moment of inertia of the card itself.

Thus, when we have reduced the moment of inertia of the solid moving system to the furthest possible limit, we may find the effect of the liquid dragged by it is equivalent to a moment of inertia several times as great as that of the card itself.

We have, in fact, a total effect of:—

First, loading the card with an additional moment of inertia;

Secondly, retarding it by a damping torque at every instant proportional to the velocity.

Both of these effects are proportional to a quantity $\sqrt{\mu\,\rho}$, where μ is the coefficient of viscosity and ρ is the density of the liquid. If we can materially reduce this quantity, we shall materially improve the behaviour of the compass.

In my opinion, a real improvement is to be looked for in the spirit compass by finding a more suitable substitute for the liquid now commonly employed.

I have already pointed out that Archibald Smith showed that to obviate the length-of-needle error, the magnetic moment (M) of the needle, and take the square root of the result, we obtain a quantity which has the dimensions of a length.

In other words we may say:

$$\sqrt{\frac{x^5\,(\sigma\,\delta x)}{M}} = a_1$$

where a_1 is a certain length.

The length a_1 (Fig. A) is important, if we can determine that we know where to place our needles. We measure it off from the centre of each needle and so dispose them that the points thus found subtend an angle of 60 deg. at the card centre.

This is the necessary modification of the Archibald Smith theory when we take into account distributed magnetism on the needles.

It now remains for us to see how we determine the amount of magnetic matter, on each element of the needle.

Imagine that the element δx is bounded by two transverse planes (Fig. B) and that we can in some way create a uniform field of unit intensity vertically downwards between these planes—in fact, imagine we have a "slab" of magnetic field of unit intensity filling the space between the planes.

The magnetic matter on the element in question will then experience a force vertically downwards equal to $(\sigma\,\delta x)$ dynes. Imagine further the needle to be attached to the scale pan of a chemical balance and this downward force be weighed. If we weigh the force in dynes, the

θ = angle measured from the meridian at which balance is obtained.
F = known magnetic force in the annular space.
l = distance from pivot to mid-point between current sheets.

We have :

$$H M \sin \theta = F l (\sigma \delta x),$$

hence the amount of magnetic matter in the element.

Fig. A.

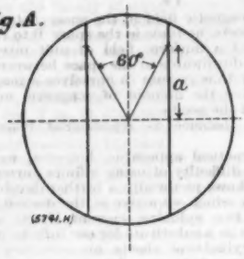


Fig. B.

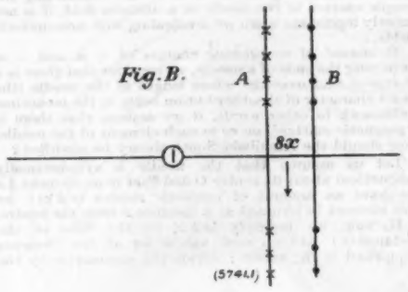


Fig. 8.

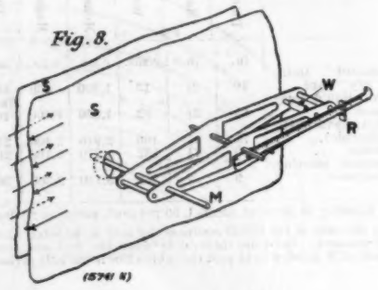


Fig. 9.

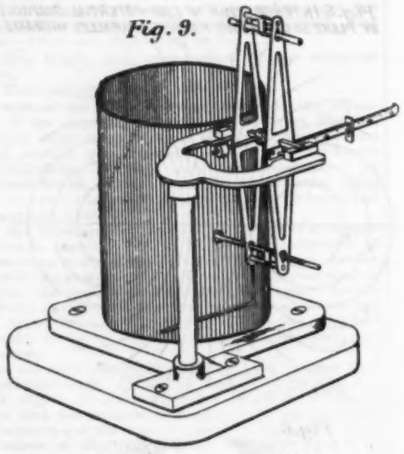


Fig. 10.

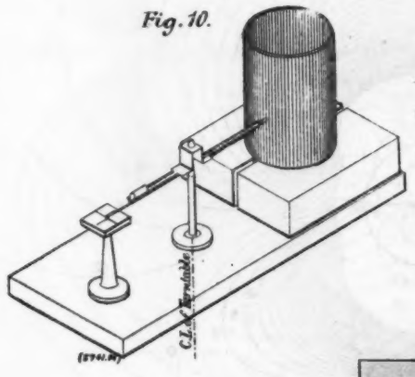


Fig. 11. SURFACE DISTRIBUTION OF MAGNETISM. ONE OF THE NEEDLES OF 6½" LIQUID COMPASS.

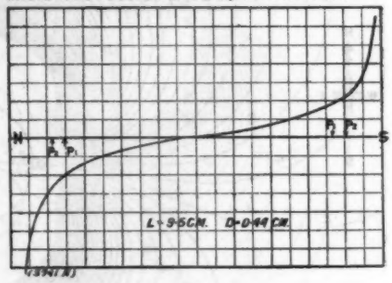


Fig. 11 shows the character of the distribution obtained in the case of some needles used in compass construction.

In making use of the arrangements described, we must satisfy ourselves that the effect of the bulging of the magnetic field out of the small hole through which we pass the needle does not produce a large error. But if the apparatus be properly designed, we can get accurate measurements up to about 5 mm. from the end of these needles.

Having determined the magnetic distribution, we have all the necessary information to enable us to determine the length a_1 and hence to correctly dispose the needles in the card.

Before proceeding to the next part of my subject, I will show you a very convenient apparatus for measuring quickly the magnetic moments of cards without removing them from their containing bowls.

Figs. 12 and 13 illustrate the apparatus in question.

It consists of a glass jar inside which a needle, arranged to be astatic in the earth's field, is suspended from a torsion head.

Each element of the needle has a strength of about 600 c.g.s. units, the elements being separated by about 10 c.m.s.

The lower one swings clear of the bottom of the jar and is immersed in damping fluid.

The spindle is supported on a fibre and controlled by a torsion spring, the ends of which are attached to the spindle, and the torsion head respectively.

The spindle carries a pointer which moves over a graduated dial, attached to, and moving with the torsion head, but arranged to be independently rotatable, so that it can be set to zero when the tension of the control spring is zero.

The jar is placed centrally on the compass bowl glass, and in this position the lower element of the astatic combination comes within range of sensible force of the card needles.

The torsion head is rotated until the card is deflected into the E—W position. We then know that the earth is acting upon the card with a torque equal to H M, and since the astatic needle is co-axial with the card, the torques mutually exerted between card and astatic system are also H M. This, however, is the only magnetic couple acting upon the astatic system, and it must, therefore, be balanced by the torsion of the control spring.

Since the one end of the spring is virtually attached to the dial, and the other to the pointer, the position of the pointer on the dial represents the amount of torsion of the spring.

The torsion head may, therefore, be calibrated to read M direct for any place where H is known, it being understood that M is indicated on the dial when the torsion is such that the card under test is deflected into the E—W meridian.

Where a very powerful card is under test, it may be deflected by only 30 deg., in which case the readings of the torsion head must be doubled.

It will be observed the accuracy of the device depends upon :—

1. The astaticism of the system, which is readily tested and adjusted from time to time, and

Fig. 12.

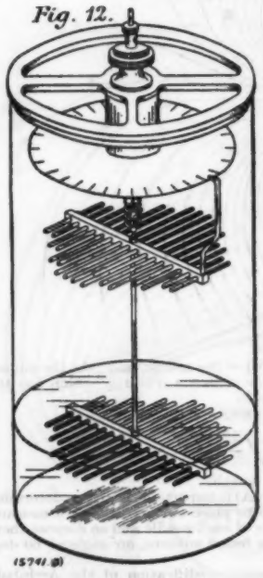


FIG. 13.

2. The calibration of the control spring. It in no way depends upon the strength of the needles of the astatic system, or upon their distance from the card.

For the purpose of measuring moments of small magnets, the apparatus is completed by the addition of a special dry bowl and card (without magnets) provided with a cradle upon which any small magnet may be placed.

Having measured the magnetic moment, the moment of inertia is most easily determined by calculation from the period of vibration.

The lecturer next pointed out the effect of magnetic dissymmetry of a card.

Suppose one of the needles of a two-needle card was materially weaker than the other, no deviation would be noticed when testing the compass in the usual way in a uniform magnetic field. In such a field both needles, no matter what their strengths might be, would tend to point along the lines of force, and the card would point "true."

When, however, the compass was placed in a non-uniform field, such as those already exhibited on the screen, an effect would arise due to inequality of magnetic strength of the two needles.

It was important to remember that dissymmetry of this character could not be detected by the usual tests made in a uniform field.

A further instance of dissymmetry might occur if the magnetisation of either needle was unsymmetric about the central plane of that needle; an illustration of this effect was given by depicting on the screen the iron filings diagrams of a "bad" permanent magnet: (*a*) Immediately after magnetisation; (*b*) six weeks after magnetisation.

The field of force which was symmetrical immediately

a. IMMEDIATELY AFTER MAGNETISATION. *b*. SIX WEEKS AFTER MAGNETISATION.

FIG. 13A.

after magnetisation, had become exceedingly unsymmetric during the interval of six weeks.

An apparatus on the lecture table was referred to by means of which needles might be rapidly tested in the workshop:—

(*a*) For equality of magnetic moment.

(*b*) For symmetry of magnetisation about the central plane of each needle.

Fig. 13a shows the effect immediately after magnetisation and six weeks thereafter.

I had intended to speak about the magnetisation of the ship and how the various correctors perform their functions, but I have occupied so much time in discussing the magnetism of the "mouse" that I have no time left to devote to the "elephant."

I have discussed the effect of long needles badly placed, and I will now conclude with a reference to the effect of employing undesirably great magnetic moments.

Briefly we may say that the earth's horizontal force induces magnetism in the ship, which in general produces an east-westerly force at the compass station and gives rise to deviation.

The function of the quadrantal globes is to neutralise this east-westerly force.

If then the globes be properly proportioned and placed, no deviation of the resultant field, due to the cause under consideration, exists at the centre of the compass.

If, then, the resultant magnetic force agrees with the plane of the magnetic meridian, may we not expect a card to point "true"? Whatever our expectations, the fact remains that it does not necessarily do so. It depends on the magnetic moment of the needles.

We may readily test this on shore. Take a binnacle with, say, 8½-in. globes set 12 in. from the central axis and turn it round until the diameter passing through the spheres is in the N.E.—S.W. direction.

We can easily calculate that the direction of the resultant field at the centre of the compass is N. 7·3 deg. E., the deviation from the meridian being due to the deflection of the lines of force by the action of the spheres. Further, this deviation of 7·3 deg. east would be the same at whatever part of the earth we might be experimenting—it does not depend on the value of H.

Now let us place cards of different moments in position, and observe the positions they take up. The following table represents a series of tests made at Glasgow:—

The first thing we notice is that the only card which takes up the direction of the resultant force is the small magnetic moment dry card.

The standard naval liquid compass is attracted 2·7 deg. further in the direction of the spheres.

Deviation Produced by 8½-in. Spheres 12 in. from Vertical Axis, on N.E. and S.W. Diameter.

—	Reading.	Inductive Deviation (Approx.).
	deg.	deg.
Standard 10-in. "dry" card	7·3	—
Standard naval compass	10.0	2·7
Torpedo boat compass	10·0	2·7
U.S.A. naval compass	11·65	4·35
Ritchie compass	18·9	11·6
Common steering compass	13·2	5·9

The Ritchie compasses, with their larger moments, are attracted 4·35 deg. and 11·6 deg. respectively, and so on.

These attractions are due to the magnetism, induced in the spheres by the powerful needles, reacting on the needles.

Now supposing we were to repeat this test at Singapore, where the value of H is about 2·3 times the value at Glasgow, should we get the same deviations? Only in the case of the small moment card; the others would be different. In fact, the third column of the above table shows the portion of the deviation, the amount of which depends on geographical position.

The quadrantal deviation produced by the ironwork of the ship does not depend on geographical position, but the amount of the compensation provided by the spheres does depend on geographical position, if the needles are strong enough to produce sensible magnetism of the spheres.

Now it is interesting to note that we do not require to go beyond the information contained in the excellent manual published by the Admiralty on the Deviation of the Compass, to obtain corroboration of the above. At the end of the manual, tables are given setting out the actual observed deviations of different compasses in the presence of globes of different sizes and situated at different distances on a quadrantal diameter.

On page 105 of the manual referred to, on a footnote, a formula is given, extracted from one of Archibald Smith's Royal Society papers, by which we may calculate the deviation of the resultant force due to the globe. I have plotted the results, and the curves are to be found in Figs. 14, 15 and 16.

Fig. 14. DEVIATION CURVES WITH 6" SPHERES.

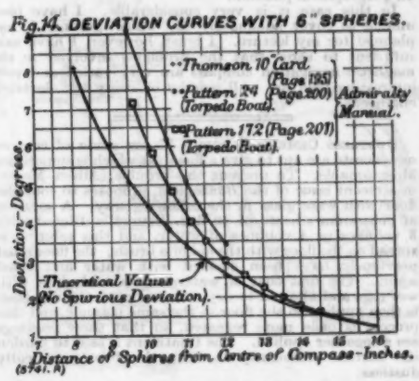

••Thomson. 10" Card. (Page 195)
••Pattern. 24 (Page 200) (Torpedo Boat).
Admiralty Manual.
oo Pattern. 172 (Page 201) (Torpedo Boat).
Theoretical Values (No Spurious Deviation).
Deviation - Degrees.
Distance of Spheres from Centre of Compass - Inches.
(5741. K)

Fig. 15. DEVIATION CURVES WITH 6½" SPHERES.

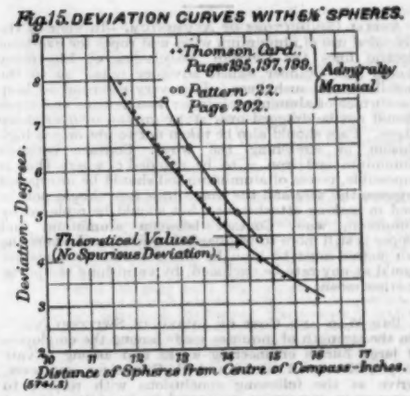

••Thomson. Card. Pages 195, 197, 199.
Admiralty Manual
oo Pattern. 22. Page 202.
Theoretical Values. (No Spurious Deviation).
Deviation - Degrees.
Distance of Spheres from Centre of Compass - Inches.
(5741. S)

Fig. 16. DEVIATION CURVE WITH 12" SPHERES.

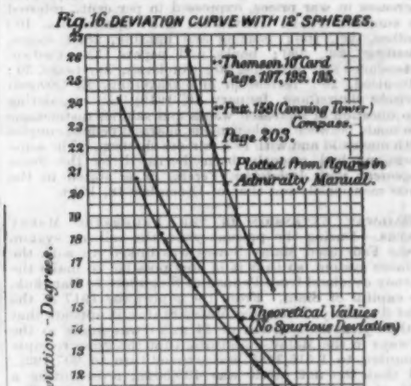

••Thomson. 10" Card. Page 197, 199. 195.
••Pat. 158 (Conning Tower) Compass. Page 203.
Plotted from figures in Admiralty Manual.
Theoretical Values No Spurious Deviation)
Deviation - Degrees.
Distance of Spheres from Centre of Compass - Ins.
(5741 Y)

Fig. 14 shows the Admiralty measurements when using 6-in. spheres.

Note how the observations for the "Thomson" (dry) card lie on the theoretical curve, while those of the naval liquid types all lie above.

The difference is the amount of the attraction towards the globes, caused by the strong magnetic moments necessarily involved in the liquid compass.

Fig. 15 shows the Admiralty observations when using 8½-in. spheres, while Fig. 16 refers to 12-in. spheres. In this case it is observable that the results for the "Thomson" card lie below the theoretical curve. The reason for this is probably to be found in the fact that the globes are hollow. The theoretical curves are calculated for solid spheres. Where the wall thickness is

sufficiently great, a hollow sphere is equivalent to a solid sphere. But in the case of the 12-in. globes, in order to keep down excessive weight, the wall thickness is less in proportion to the diameter, and the effect in deviating the earth's field is less than the theoretical value for solid spheres. In spite of this, the observation for the liquid-pattern compass, known as the 158 Pattern, are away above the theoretical curve.

If this explanation be the correct one, we should take the difference between the "Thomson" and the Pattern 158 curves as representing that portion of the deviation in the latter case, the amount of which depends on geographical position.

In this case it is very considerable. I have been unable to cover adequately the whole ground I had planned for my lecture. I trust, however, I have said sufficient to show that the problems involved in the magnetic navigation compass are very varied and very interesting, and are well worthy of study by electrical engineers.

Dustless Cement Floors.—Floors made of cement or concrete are apt to give a fine dust which is sometimes objectionable. To prevent this trouble, Albert Meyer, in a recent issue of the *Bauzeitung*, proposes to coat the floor with waterglass in the following way. A solution of potassium silicate of 40 deg. Baumé is diluted with 3 volumes or 4 volumes of water, and this solution is spread on the floor with the aid of a brush; the floor must previously have been cleaned with water and dried again. The first coat of waterglass is rubbed in with wet rags and allowed to dry. A new coat of waterglass is then applied to the floor in the same manner, and this process is once more repeated, so that three coatings are altogether applied. The treatment is said to harden the surface sufficiently to keep the floor practically dustless.

Aerial Conductors of Aluminium.—In view of the extended use of aluminium wires and ropes for overhead electric lines the German Association of Electricity Works last October issued advisory notes as to the installation of such lines. It is very essential to keep the surface of aluminium intact; hence wires and ropes should not be dragged over stony ground or over sharp edges. Care should also be taken not to put on too high tension in stretching the wires. Contact between aluminium and iron is to be avoided; where that is impossible, pieces of aluminium foil should be interposed between the wire and the iron; iron wire should not be used in making attachments, but should be replaced by aluminium wire. Contact between aluminium and copper is still more to be guarded against, and where the two metals must be brought into contact, the moisture should at any rate be excluded, by varnishing the parts, or other means.

The War and Cost of Living in Switzerland.—On the strength of inquiries made among the employees of large Zürich engineering works and among private people, Messrs. R. Dubs and B. Graemiger, engineers, arrive at the following conclusions with respect to increases in war prices, expressed in per cent., referred to summer, 1914: Provisions, 145; apartments, 10; clothes, &c., 105; heating and lighting, 285; wages, cleaning, &c., 280; books and papers, 15; medical attendance and medicine, 30; purchases, 70; taxes, 30; education, 20; recreation and travelling, 43 (*Schweizerische Bauzeitung*, January 18, 1919). In considering the question of increased wages and salaries distinctions are made between single persons, married people, couples with one child and with two or more children. The same questions had recently been discussed by the Swiss *Ingenieur und Architekten Verein*, as is stated in the issue mentioned, and that of December 18, 1918.

Railway Extension in the Federated Malay States.—During the present year, the railway system of the Federated Malay States was linked up with the Siamese system, so that it is now possible to make the journey overland from Penang or Singapore to Bangkok, the capital of Siam. From the report for 1917 of the Chief Secretary, Federated Malay States, it appears that in that year an addition of 54 miles was made to the railways in the Malay Peninsula, that the gross receipts amounted to 1,515,388*l.* and expenditure to 907,193*l.*, and that the net profit was 486,304*l.*, representing a yield of 3·95 per cent. on capital expenditure. The increase on gross receipts over the previous year amounted to 181,899*l.* The total train mileage in relation to traffic receipts was 3,491,741, an increase of 65,809. The number of passengers carried was 12,037,941, a decrease of 2,703,125. Goods traffic increased by 26,373 tons, the total carried being 1,293,404 tons. Live stock increased by 22,382 head, the number carried being 144,809. The falling-off in passenger traffic was due to the increase of fares, which had effect from March 1, 1917. Passenger traffic had been increasing to such an extent that the department was unable to cope with it. The number of trains could not be increased owing to the impossibility of obtaining more locomotives. Some of the engines ordered from England, which it is understood were completed to the extent of 80 per cent., could not be delivered, and attempts to secure them from foreign countries were unsuccessful. The engine difficulty was not entirely due to the shortage of engines. There was, at the time of writing, also a great difficulty in obtaining materials for repairs to locomotives. Goods traffic, however, was fully maintained by the restriction of passenger traffic. The amount spent on railway construction during 1917 was 224,998*l.*, and the item of 100,000*l.* appears in the railway accounts as a "Contribution to the Imperial Government."

CATALOGUES.

Re-inforced Concrete.—We have received from the British Reinforced Concrete Engineering Company, Ltd., of 1, Dickinson-street, Manchester, a set of tables showing particulars of floor slabs suitable for every variety of use, from roofs and the floors of dwelling houses, up to heavy warehouse and machine-shop floors. The reinforcement used consists of a steel wire fabric, the wires being of a high quality of mild steel with an elastic limit of 75,000 lb. per square inch, and an ultimate strength of 80,000 lb. to 100,000 lb. per square inch. The tables are mounted on a very stiff board, and are faced with celluloid, and can thus be kept clean and legible under even the most unfavourable surroundings.

Water Heating.—A special form of water-heating boiler is described in a catalogue received from Mr. Arthur Roberts, 27, Leyfield Road, West Derby, Liverpool. The illustration at first suggests a fire tube boiler of square form, with outer water casing. There is a considerable difference, however, in the path laid out for the hot gases. These return from the back of the furnace through side flues and enter the tubes at the front, then pass through the tubes and away to the smoke-box at the back. This avoids the most intense heat striking on the tube ends, and provides side flues surrounded by water. The method of construction promotes the strong circulation required in water heating. The fire-box is of steel and the tubes of wrought iron. The design makes for easy access to all parts for cleaning, takes up the least possible floor space, and gives a neat smooth appearance. It is known as the "Mersey" boiler.

Abbe Refractometers.—The new catalogue on their Abbe refractometers which Messrs. Adam Hilger, Limited, of 75A, Camden-road, N.W. 1, send us, deals with instruments that are more and more coming into general use for testing the purity and density of oils, fats, waxes, solutions in water, alcohol, and other solvents, drug and tannin extracts, petroleum products, paints, varnishes, sugar, &c. The rapid determination by these instruments of the refractive index and dispersion of a few drops or a film of the substance gives valuable information also about other properties so that refractometers are replacing hydrometers and specific-gravity bottles. We described the new form of Abbe refractometer in our issue of September 13 last. We should add that since October last Messrs. Hilger supply the instruments standardised with interchangeable parts. Particular care is taken in standardising the Abbe prisms. A melting of suitable glass having been obtained, a piece is cut from every block of the melting; the pieces are polished plane-parallel and welded by the patented process of the firm (also described in our columns) to form one piece which is polished plane-parallel in a direction at right angles to the former; this plate is then examined for difference in refractive index by the Hilger interferometer, and the melting is rejected if the variations in index exceed 0·00001.

The Economical Situation in Germany.—A resolution was unanimously passed at a joint meeting held last December, of the Rhenish-Westphalian and South Westphalian Chambers of Commerce, of the North-Western Group of the Union of German Iron and Steel Manufacturers, the Union for the Protection of the Common Economic Interests in Rhineland and Westphalia, and others, stating that "unless stringent measures are taken at once to establish peace and order, and to ensure the development of the economic life, our (the German) present situation will lead to a collapse even more terrible than the political catastrophe of our Fatherland. It might be asked whether the enemy really intends to add Germany's economic destruction to her political ruin, for the dealings in connection with the armistice terms would seem to infer that such was the case . . ." The taking, or not, of "stringent measures" within her own borders is Germany's own concern, but dealing more particularly with the remaining portion of the above paragraph, we find the sentiment it gives expression to fully confirms the well-known statement to the effect that "a German is quite unable to win like a gentleman or to lose like a man." What had been Germany's intentions, if not to add the Allies' economic destruction to their political ruin?

Anglo-Swedish Steam Ferry Connection.—The question of the arrangement of better shipping connections between Sweden and England has long been under discussion, says *Swedish Export*. A few months before the outbreak of war some specially-appointed experts made a report on the subject, which has since been the subject of examination in the Board of Trade, which expressed itself in favour of the project of daily connection so far as to propose a comprehensive and speedy examination of that question. On the strength of a number of inquiries into the matter the Board came to the conclusion that a daily steam ferry connection was expedient and that four steam ferries of 11,000 tons displacement, when fully loaded, and loading 3,000 tons deadweight would be required for the purpose. Mr. Schotte, the Home Secretary, has declared in an interview that the question of a steam ferry connection, or possibly a daily steam boat connection, between Sweden and England is the subject of extensive and searching investigation on the part of the Government authorities. It is the intention to try and arrange this important traffic question as soon as possible. No definitive decision is to be expected within the immediate future; but if there is any possibility of laying the matter in any form before the Riksdag next spring, the Minister, for his part, would not fail to take the necessary steps.

COMMISSION ON INTERNATIONAL LABOUR LEGISLATION.

The following official *communiqué*, dated February 1, 1919, has been received from Paris, and is passed to the Press for publication: The Commission on International Labour Legislation met this morning at 11 a.m., at the French Ministry of Labour. There were present: Mr. Gompers and Mr. Hurley, America; Mr. Barnes and Sir Malcolm Delevingne, Great Britain; M. Colliard and M. Louchour, France; M. Mayor des Planches, Italy. For the States represented by five delegates: Mr. Vandevelde and Mr. Mahain, Belgium; Mr. Benes, Czeche-Slovakian Republic; Mr. Zoltowski, Poland; Mr. Martinez, Cuba. Mr. Colliard, Minister of Labour, in opening the sitting, delivered the following address: I am happy to welcome you here at the Ministry of Labour which is specially interested in promoting your deliberations. At a time when representatives of the nations are gathered together to endow the world with a real organisation of its associated democracies, the work which we are to undertake assumes a special importance. Indeed the task which we are called upon to perform will assure the establishment of the democratic idea in the economic sphere, and will complete the significance of the Peace Treaty by guaranteeing the dignity and liberty of human labour by means of International Conventions by the inquiries and researches which we think should be undertaken, as well as by the decisions which we shall take here. We shall have to establish the organisation of a conference at which the productive forces of every nation shall be represented. On that conference will devolve the duty of actually drawing up the international labour charter and of guaranteeing its observance. In order that that conference may arrive at the results for which we hope as rapidly and as effectively as possible, it would certainly be desirable that our Commission should indicate the questions it should first examine. Its first duty would appear to be to review and complete the work of the previous conferences held with similar aims, then to examine the most urgent problems connected with the condition of employment and the protection of the workpeople, and boldly to devise the necessary measures for dealing with these matters. In the first place we are called upon to appoint the officers who will direct our proceedings. I take the liberty of proposing Mr. Samuel Gompers as President of the Commission. No one appears to be better qualified for this position than the president of the largest and most powerful trade union organisation in the world, and our choice would, moreover, be an appropriate testimony to one whose life has been devoted to the interests of the workers and to the struggle for social justice.

The Commission then proceeded to the election of officers. Mr. Gompers was unanimously elected president. It was decided to set up a general secretariat. Mr. Arthur Fontaine, Directeur du Travail, was appointed general secretary, and Mr. H. B. Butler, C.B., of the British Ministry of Labour, Technical Adviser to the British Delegation, assistant general secretary. The conference also decided to nominate two secretaries—one Italian secretary, M. di Palma Castigliono, and one Belgian secretary, to be appointed later—whose duty it would be to represent the interests of the nations represented by the five delegates chosen at the special conference. The Commission fixed its next meeting for Tuesday last, February 4, at 5 o'clock.

The Industrial Position of Luxemburg.—Although the severance of Luxemburg from the German Customs Union is a heavy blow to the German iron industry, it is admitted that the Grand Duchy was perfectly right in doing so, Germany having, amongst other things, violated the mutual railway agreement which was closely connected with the customs arrangement. It is further openly admitted that it would be a suicidal policy for Luxemburg if she did not sever her connection with Germany under the present, entirely different conditions. Luxemburg will now have to secure new connections in a Western direction, with which country remains to be seen. The industrial reconstruction in Luxemburg will, in the first instance, apply to the iron industry, and it has been predicted that this industry, without material trouble, will be able to adapt itself to the altered circumstances. There is all the more reason to take this view, as the Lorraine district is not likely to be closed for Luxemburg, and that the barriers which hitherto have existed between Luxemburg on the one side and France and Belgium on the other, will probably be done away with. That Luxemburg may have to forego her supply of German coal is, of course, an adverse condition, but the Germans themselves admit that there are several factors which are likely to counterbalance any drawback from this point of view. First amongst such factors may be mentioned the higher development of the iron industry within the Grand Duchy, of which Luxemburg will hereafter reap the benefit and which will give her an advantageous position as compared with the similar industries of Belgium and France. The reconstruction of industries and the reversion to a peace footing is also likely to give the Luxemburg iron industry less trouble than the German. On the other hand, the Luxemburg iron industry will, no doubt, have, like other countries, to face some fresh taxation measures, although much less stringent than those necessitated in Germany. The 8-hours' day, which has been introduced by way of experiment in the mining and iron industries, means also an increased cost of production. The shortage of coke has already made itself seriously felt, and many of the iron works have had to close down blast furnaces.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

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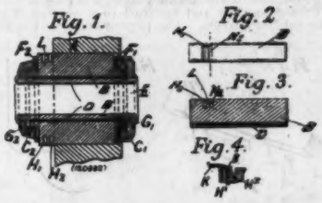
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.

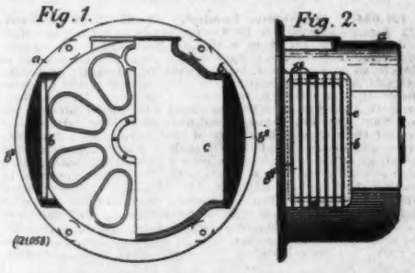
ELECTRICAL APPARATUS.

120,982. H. C. H. Smyth, Chiswick, London, and Tredelect Engineering Company, Limited, Chiswick, London. Commutators. (7 *Figs.*) November 29, 1917.—According to the invention, the leads to the commutator segments are formed with T-shaped heads fitting into transverse slots in the segments. Close to each slot, and parallel to it, is a second slot formed in the segment, into which a caulking tool is inserted, so as to bend over the intervening metal strip between the two slots and effectively squeeze the lead in good conducting contact with the segment. A represents a disc, which may be the chuck of a lathe, in which the segments temporarily secured by a wire, are



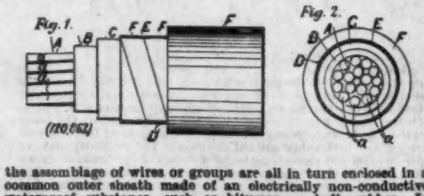
held; C^1 and C^2 are the turned-down ends of the segments, D fibre envelopes insulating each segment from a steel tube E and from the adjacent segments. G^1 and G^2 are metal caps holding the segments in position against centrifugal force, and F^1, F^2 fibre insulation between the caps and the projecting rings C^1, C^2. The tube E pressed over at each end forms a sort of ferrule securing the metal caps G^1, G^2, and firmly binding all parts together. H^1 and H^2 are two parallel slots in a segment B; when the T-shaped end of a double lead K has been inserted in the slot H^1, the intervening strip L of metal between the slots H^1 and H^2 is caulked over so as to secure the lead in its slot. (*Accepted December* 11, 1918.)

121,058. W. F. Higgs, Birmingham. Dynamo Electric Machines. (2 *Figs.*) February 13, 1918.—The invention relates to dynamo electric machines of the types provided with a casing. In machines of the types referred to apertures or inspection openings are provided in the cast-iron or steel castings at the commutator or in the slip-ring cover of the machine, and these apertures or openings are ordinarily provided with metallic grid-like or open mesh doors or covers. According to this invention, there is combined with the metallic grid-like aperture



covers a piece of glass, or pieces of glass, of a size and shape proper to fill or cover the aperture to which the cover is to be applied. *a* is the end cover of a dynamo, and *b*, b^2, are the detachable grids over the inspection opening in the end cover *a*; *b* being the frame of the grid and b^2 being the parallel bars of the same. On the inner side of each grid *b*, b^2 is a rebate for the accommodation of a piece of glass *c* (see the right-hand half of Fig. 1), but the rebate may, if desired, be made in the edge of the inspection opening of the end cover *a*. (*Accepted December* 11, 1918.)

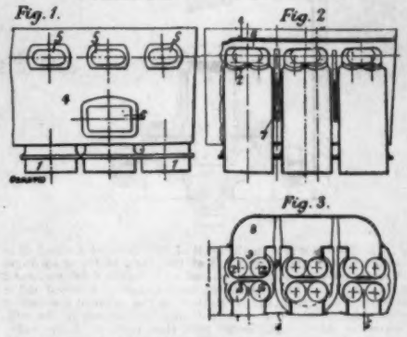
120,962. W. T. Henley's Telegraph Works Company, Limited, London, and H. Savage, Blackheath, London. Electric Cables. (2 *Figs.*) November 26, 1917.—This invention relates to electric cables of the kind wherein a dielectric covering is applied to each wire or group of wires for the purpose of insulating it from an adjoining wire or group, and wherein



the assemblage of wires or groups are all in turn enclosed in a common outer sheath made of an electrically non-conductive waterproof substance, such as bitumen or india-rubber. In accordance with the present invention, a thin strip or tape made of a conductive material is applied over the covering of dielectric material and between it and the inner surface of the sheath in such manner as to completely envelop the dielectric material. A is the conductor built up of a plurality of wires *a*, *a*, whilst B and C are layers which, together, constitute the dielectric covering for the current-carrying wires *a*, *a*. D is a metal strip wound spirally over the layer C and laid with such a pitch that the contiguous edges of the strip in successive convolutions are in contact with each other so as to completely envelop the dielectric covering, said strip being permanently connected to earth or to the neutral point of the transmission system. E is a strip of material (of an insulating nature or not) which may be laid over the edges of the conductive strip to prevent the edges of the latter from cutting or damaging the outer sheath F when the cable is bent, said sheath consisting of an electrically non-conductive waterproof substance, such as bitumen or india-rubber. (*Accepted December* 11, 1918.)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

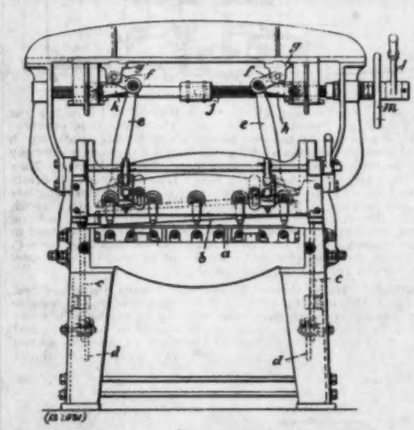
120,873. F.I.A.T. Societa Anonima, Torino, Italy. Internal-Combustion Engines. (8 *Figs.*) March 14, 1918.—According to this invention, the tubes leading the mixture from the carburettor to the cylinders are wholly or partially surrounded by the water circulating in the jacket. 1 are the cylinders, 2 the seatings of the admission valves, 4 is a sheet metal water jacket. The jacket has at one side exhaust apertures 5 and a



lower central aperture 6, to which the carburettor is directly connected. From the aperture 6 starts a pipe which divides into tubes 7, that pass between the engine cylinders, transversely upwards within the water jacket and into a collector 8; the mixture from the carburettor is distributed from the collector 8 to the admission chambers 9 of all the engine cylinders. The piping 7 is thus almost throughout surrounded by hot water circulating in the water jacket. (*Accepted December* 4, 1918.)

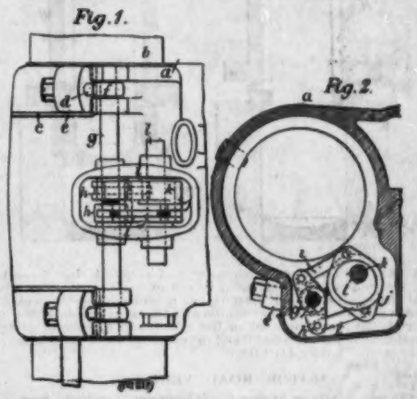
MACHINE AND OTHER TOOLS, SHAFTING, &c.

121,031. T. H. Webb, Wakefield, and C. J. Rhodes, Wakefield. Metal Shearing Machines. (1 *Fig.*) February 2, 1918.—This invention relates to metal-working machinery of the type involving a moving member which is operated by two pairs of toggle links located in opposed relationship with each other, and actuated by right and left-hand screw threads. In a convenient embodiment of the present invention, *a* is the lower stationary cutter, and *b* is the upper moving cutter. The cutter *b* has, at each extremity, a depending rod *c*, which is coupled to a pivoted counterweight *d*. Near to each extremity of the upper cutter, the lower extremity of an upwardly extending toggle link *e* is pivoted. These two toggle links converge slightly upwardly, and, at their upper extremities, they are pivotally



coupled to the extremities of two short divergent links *f*, the other extremities of which are pivotally coupled to fixed bearings *g*. *h* are toggle operating links which extend in opposite directions, substantially horizontally, to points at which they are pivotally coupled to nuts which work upon a horizontal screwed shaft *j*. Rotation of the nuts is prevented. The threaded shaft has right and left-hand quick screw-threads, one for each nut, and conveniently may be made in two parts. At one end the shaft projects beyond the bearing and carries a lever *l* by which it is rotated to straighten the toggles and so cause the cutter *b* to descend. This extension of the shaft also carries a hand-wheel *m* by which the moving cutter can be raised. (*Accepted December* 11, 1918.)

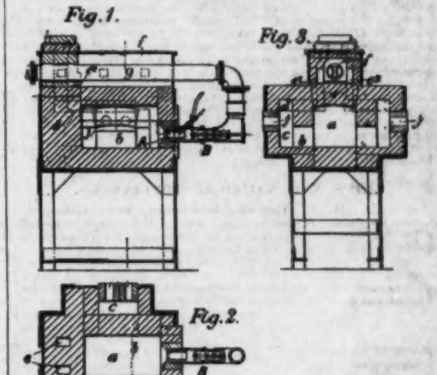
121,037. James Archdale and Co., Limited, Birmingham, and J. Jewsbury, Handsworth, Birmingham. Radial-Arm Drilling Machines. (2 *Figs.*) February 13, 1918.—The invention comprises the combination with two co-axial and separate shafts respectively connected to two independently operable parts of the locking mechanism, of a lever on each shaft, an eccentric carried on an operating shaft parallel with the first-mentioned or locking shafts, a lever actuated by the eccentric, and links connecting the latter lever to the locking-shaft levers, the arrangement being such that rotation of the eccentric can operate the locking shafts either conjointly or independently. In applying the invention to a radial arm sleeve *a* movable on a cylinder pillar *b*, the sleeve is slotted at *c* at each end so that it can be clamped tightly on to the pillar. Clamping means consist of a bolt *d* which engages a lug *e* on one side of the slot, and is actuated by the eccentric portion *f* on a shaft *g* carried in bearings on the opposite side of the slot. Rotation of the shaft in one direction causes the eccentric to impose a tension on the bolt which contracts the slot and so causes the sleeve to grip the pillar. The two locking shafts *g* are independently movable and arranged co-axially. At their adjacent ends each locking shaft has secured to it a lever *h*, and both levers are connected by links *i* to the opposite ends of another lever *j*, which



is bored out to embrace an eccentric *k* secured to a third or operating shaft *l*, mounted parallel with the locking shafts. Preferably the locking shaft levers are so disposed that rotation of the eccentric by the operating shaft rotates the locking shafts in opposite directions. Assuming both locking mechanisms to be free, movement of the operating shaft in the appropriate direction causes the locking shafts to move together. If one of the locking mechanisms is fully tightened before the other, continued movement of the operating shaft causes the shaft of the other locking mechanism to move independently. Consequently, complete tightening of both locking mechanisms can be insured. The opposite movement of the operating shaft releases the mechanism. (*Accepted December* 11, 1918.)

MINING, METALLURGY, AND METAL WORKING.

121,100. Burdons, Limited, Bellshill, and W. M. Burdon, Bellshill. Glory Hole Furnaces. (5 *Figs.*) August 9, 1918.—This invention relates to furnaces as used by glass bottle manufacturers and others, characterised by glory holes. Under the invention, the furnace is characterised by special hot chambers with which the glory holes communicate, these hot chambers being arranged at each side of a central firing chamber into which plays the flame from the burner. The furnace is heated by a burner A, B. The hot gases from the burner pass into the central firing chamber *a*, and then escape sideways through the passages *b*, *b* to the special chambers *c*, *c*, one at each side, from whence the gases pass upwards by the flues *d*, *d* to the outlet flue *e*, *e*,



from which the gases can pass by passages *d*² into the chamber *f*, in which the air supply pipe *g* of the burner is located, and highly heat the air passing through said pipe, the gases finally escaping round about the air pipe. As will be seen, the glory holes *j* communicate with the chambers *c* and consequently glass bottles inserted through the glory holes do not come into direct contact with the flame playing within the chamber *a*. The gases in the chambers *c* only escape through the small outlets *d*, with the result that there is a certain amount of back pressure in the chambers and the hot gases pass out through the glory holes, thereby very effectively heating the glass articles inserted in the holes. (*Accepted December* 11, 1918.)

121,104. Societe Schneider Cie, Paris, France. Making Metal Cylinders. (5 *Figs.*) May 6, 1918.—A method and apparatus for making, at a single heating, cylinders which are open at one end and closed at the other end and have a protecting collar intermediate of, and at any distances from, the ends is characterised in that the blank L from which the cylinder is to be made is, for the purpose of forming the collar, subjected, during the first phase of the pressing operation, to the simultaneous actions of two concentric punches E and F-H, between which is provided an annular space, the outer punch F-H pressing the blank for the formation of the collar by pressing the metal between the lower face of the said punch and a shoulder *e* in

the mould C, the upper part of the cylinder being at the same time formed by metal being forced into the annular space between the two punches. The outer punch F-H comprises a socket guide F that is supported on the blank to be pressed and fits into the mould C, the said socket guide having a lateral projection F_1, which limits its travel, and being kept at a constant

Fig. 1.

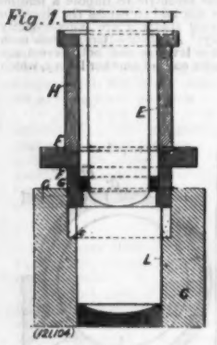
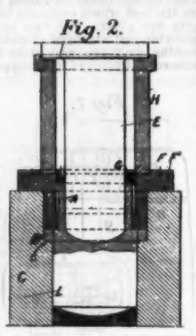


Fig. 2.



distance from the inner punch by an interposed ring G, said socket guide being surmounted by a sleeve or distance piece H by means of which the inner punch E transmits to the socket guide pressure from the press, the withdrawal of the sleeve-piece permitting the boring out of the cylinder to be effected after the formation of the collar B and the upper part A of the cylinder. (*Accepted December* 11, 1918.)

MOTOR ROAD VEHICLES.

121,089. Albion Motor Car Company Limited, Scotstoun, T. B. Murray, Scotstoun, and G. Pate, Junior, Scotstoun. Rear-Axle Structures. (2 *Figs.*) July 2, 1918.—The invention relates to motor vehicle rear-axle structures of the "banjo" type, in which a central annulus, in which is arranged the transmission gearing, is formed integrally, or is built up as an integer with laterally extending axle arms. In carrying out the invention—which is applicable to worm driven axles—the annulus is arranged in or near the vertical plane, and in order that it may accommodate the worm gearing without being unduly large in diameter, it is offset vertically so that its axis lies either above or below the transverse axis of the arms

Fig. 1.

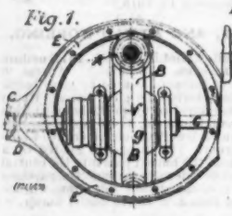
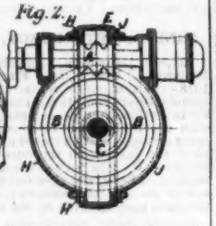


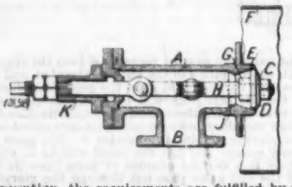
Fig. 2.



and the axle shafts within them. There is thus produced an axle structure, the annulus of which, while accommodating a worm transmission, lies in a position in which its strength is used to the best advantage and is at the same time readily and economically machined. The worm A is arranged above the usual differential casing with its external worm wheel B and laterally-extending axle shafts C, which are housed within the axle arms D. Worm, differential casing and worm wheel all lie within the circle of the annulus E, the centre *f* of which lies above the axis *g* of the axle shafts and arms. The banjo portion being thus of annular form is easily machined, while the usual outer covers H, J, for that reason are also easily machined and fitted. (*Accepted December* 11, 1918.)

SHIPS AND NAUTICAL APPLIANCES.

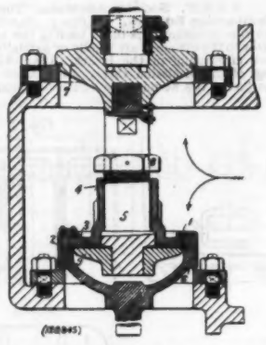
120,516. H. E. Yarrow, Scotstoun, near Glasgow. Marine Engines. (1 *Fig.*) May 2, 1918.—It has been proposed to eject waste gases of marine furnaces through ducts leading to the sides or stern of a vessel in order that the vessel may be rendered less visible to hostile craft. In such systems it is of advantage to induce a draught in the ducts by means of water sprayers, and it is of importance that the sprayers should be designed to have the greatest efficiency in order that the size of the ducts may be reduced as far as possible. Experiments have shown that the best results are attained when the spray is ejected into the duct in the form of a cone in which the water is distributed as uniformly as possible at every part of the cross-section of the cone. It is very difficult in practice to obtain this equality of flow at all parts by accurate centering of the valve controlling the jet by careful workmanship, but according



to the invention, the requirements are fulfilled by securing the valve to a spindle which is adapted to automatically centre the valve in its fixed seating under the action of the issuing cone of spray. A is a casing into which the water is forced through the inlet B; C is a valve between the conical periphery D of which and the coned seating E the water passes to issue as a conical spray into the duct F. A spindle H is secured to the cylindrical stem G of the valve and is jointed at right angles so as to be able to adjust itself in any plane to maintain the valve C in accurate axial alignment with its seating under the action of the issuing jet. The casing A is coned at J so as to form a restricted passage for the water before entering the coned seating E. The spindle H is screw-threaded at its outer end and engages with a thread on the internal surface of a gland K, so that by rotating the squared end of the spindle the opening of the valve C can be adjusted as required. (*Accepted November* 20, 1918.)

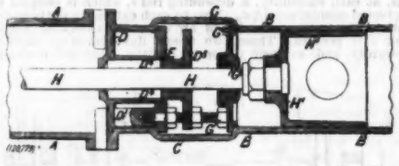
STEAM ENGINES, BOILERS, EVAPORATORS &c.

120,845. Cockburns, Limited, Cardonald, near Glasgow, D. Cockburn, Cardonald, near Glasgow, and D. MacNicoll, Cardonald, near Glasgow. Valves. (1 *Fig.*) March 28, 1918.—This invention relates to double-beat valves of the type fitted with a flexible diaphragm for effecting the balancing of the valve while serving to compensate for unequal expansion. There is fitted to the beat, which is held on its seat by the fluid pressure, a thin flexible metallic diaphragm 1, which is imprisoned in a cell between the valve element 2 and a covering member 3, secured to valve element 2, and enveloping the valve spindle 5. To counteract tendency to upset the balance of the valve by pressure of fluid which has passed to the further side of the valve seat, and urges the valve in the direction away from its



seat, a port 6 is formed in the shell of the valve element 2 so as to admit to the diaphragm cell at the back of the diaphragm fluid under pressure which has passed between the valve element 2 and its seat. In other respects the valve element 2 is closed on the side beyond the diaphragm 1, so that, in the event of fracture of the diaphragm, fragments thereof may be trapped in the cell. In screw-threaded engagement with that portion of the valve spindle 5 between the beats is a nut 8 adapted to be rotated until jammed against a sleeve-like extension 4 of the covering member 3, when the diaphragm will be compressed between the covering member and a backing member 9 secured to the valve spindle 5 at the back of the diaphragm 1, and both valve elements 2 and 7 will be seated simultaneously to permit grinding of the valve faces of both seats. (*Accepted December* 4, 1918.)

120,779. S. E. Alley, Westminster, London. Steam Engines. (2 *Figs.*) November 24, 1917.—The invention relates to double-acting cylinders for steam engines, and has for its object an improved and simple construction in which the cylinder and the crosshead guide are formed integrally. According to the invention, the forward cylinder cover—that is, the one adjacent to the guide—is inserted from the rear end of the cylinder and is secured in place by an annular flange which is inserted through a lateral aperture in the bridge part of the main casting made of dimensions to pass it, and closed by a door. The cylinder A, its co-axial cylindrical crosshead guide B, and the connecting bridge-piece C between them, are formed in-



tegrally. The forward cylinder cover D is inserted from the rear and rests in a counterbored recess. The cover D is provided with a series of upstanding pillars D^1 to receive studs, which pass through an annular flange E inserted through a doorway in the bridge-piece C and engaging a shoulder therein. Nuts on the studs serve to draw the flange E and the cover D firmly into place. In the cover D there is provided a usual stuffing-box D^4, the packing in which is held tight by a flange D^5, through which the studs also pass, and which is drawn up by nuts on them. Nuts G on the ends of the studs further serve to hold in place, against a shoulder in the forward part of the bridge-piece C, a closure plate G^2, provided with a stuffing-box G^3. (*Accepted December* 4, 1918.)

120,656. H. A. Hewat, Glasgow. Steam Superheaters. (6 *Figs.*) December 12, 1917.—The present invention is applicable to steam superheaters of the type in which an admission header *f* and a discharge header *e* are arranged parallel to each other and with their axes in the same horizontal plane, and are enclosed in a packed chamber *d*, and in which a plurality of tubular

Fig. 1.

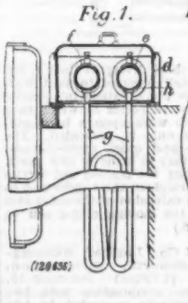
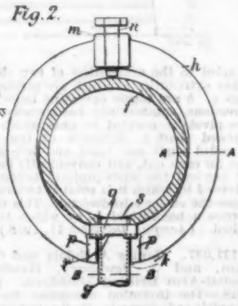


Fig. 2.



elements *g* are connected at their two ends to the two headers respectively. The invention consists in a method of connection characterised by the fact that the two ends of each tubular element *g* are vertical and are connected to the bottoms of the two headers *e*, *f* by clamps A, an independent clamp being employed to connect each end of each element to its header, each clamp consisting of a member which encircles the header and grips the end of the element and pulls it up to make a tight joint with the header round a hole provided in the latter for communication with the interior of the element. Each of the clamps A is of oval shape, with its major axis vertical, being formed with a gap *k* at its bottom and a boss *m*, with pinching screw *n*, diametrically opposite. The gap is provided with stiffened jaws *p*, *p* between which is placed the end of the tubular element *g* on the upper end of which is secured a collar *q* with recesses *r*, *r* adapted to receive the inner ends of the jaws *p*, *p*. The pinching screw *n* is screwed down on the header *f* and thus pulls up the clamp, the jaws of which press the collar *q* against the header. The header is provided with a hole *s* (for each element), this hole being opposite the end of the element so as to establish communication between the interior of the element and the interior of the header. (*Accepted November* 27, 1918.)

TEXTILE MACHINERY.

120,221. A. Newton-Smith, Westminster, London. Loom Pickers. (3 *Figs.*) July 27, 1917.—Picking mechanism of looms, in accordance with this invention, comprises, in combination, a picker without a picker foot mounted on a picking spindle of such cross-section that angular movement of the picker in relation thereto is prevented, and a picking strap attached to the picker, either around the picking spindle or below the picking spindle and above the shuttle buffer. A metal plate (Fig. 2) is subjected to operations which result in the formation of a slot *m* and a portion *n*. The portion *p* is then bent into the form of a tube. The cross-section of the tube and its internal dimensions are such that it can be passed on to the picking spindle 2, on which it will be incapable of angular movement relatively thereto. The portion *n* is bent into the form of a truncated cone, which receives the impact of the shuttle and acts as a buffer. The slot *m* comes just below the tubular portion; one end of the picking strap 5 is passed through the slot *m*, turned upward and fastened to a portion of the strap above the tubular portion. The picking strap is thus prevented

Fig. 1.

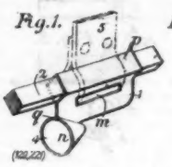
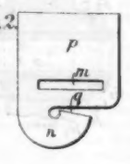


Fig. 2.



from rubbing on the picking spindle 2, and the picking effort is applied coaxially with the picking spindle 2. The edge *q* of the portion *n*, when the cone is formed, is not attached to the other portion of the part *n*, so that when the shuttle strikes the cone, it (the cone) will yield to the impact as a spring and act as a buffer. Alternatively, the part *q* may be welded to the portion *n*. As the cone is truncated, the metal tip of the shuttle is protected from injury as it passes through the opening at the inner end of the cone, which opening also acts as a vent for the escape of the air that is trapped by the shuttle, when it enters the cone. For the same purpose, the cone may be pierced with small holes, and to soften the impact of the shuttle, its outer or larger end suitably shaped so as to hold securely soft metal or other material. The picking spindle 2 is shown as rectangular in cross-section, the tubular portion of the picker being shaped to correspond. It will be understood that the shape of the picking spindle prevents angular movement of the picker in relation thereto and that the picker foot, which is usually employed for this purpose, is unnecessary. (*Sealed.*)

MISCELLANEOUS.

121,034. W. Skaife, London. Tanks and Cisterns. (12 *Figs.*) February 6, 1918.—The seams of a tank are made and afterwards sealed in a liquid-tight manner, by causing projecting parts of one metal sheet to pass through recesses or slots in an adjacent sheet, bending over the outwardly-projecting parts of each sheet towards the outer surface of the adjacent sheet, slipping a bent metal covering strip over the bent-over projecting parts so as to become engaged therewith, pressing the covering strip and engaged bent-over projecting parts closely against the corresponding sides of the tank, as by a hydraulic press, and finally completing the sealing of the seams by molten metal, as by dipping the tank into a galvanising bath. Each edge of each of the metal sheets *a* that is to be connected to another sheet to form adjacent side walls of a tank, is formed with teeth *b* that are bent over into a position more or less at right angles to the plane of the sheet (see Figs. 1 and 2), the teeth on each sheet being adapted to extend dovetail fashion through the spaces *c* left between the teeth of adjacent sheets, as shown in Fig. 3. A covering strip *d* of sheet metal, bent lengthways-

Fig. 1.

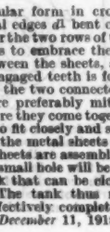


Fig. 3. Fig. 4

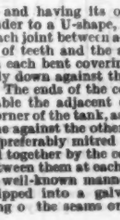
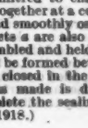


Fig. 2.



to an angular form in cross-section, and having its opposite longitudinal edges *d*1 bent over and under to a U-shape, is then slipped over the two rows of teeth *b* at each joint between adjacent walls, so as to embrace the two rows of teeth and the angular corner between the sheets, after which each bent covering strip with the engaged teeth is forced tightly down against the outer surfaces of the two connected sheets. The ends of the covering strips *d* are preferably mitred to enable the adjacent ends of strips, where they come together at a corner of the tank, as shown in Fig. 5, to fit closely and smoothly one against the other. The corners of the metal sheets *a* are also preferably mitred so that when the sheets are assembled and held together by the covering strips *b*, a small hole will be formed between them at each corner of the tank that can be closed in the well-known manner by a rivet *f*. The tank thus made is dipped into a galvanising bath to effectively complete the sealing o the seams or joints. (*Accepted December* 11, 1918.)